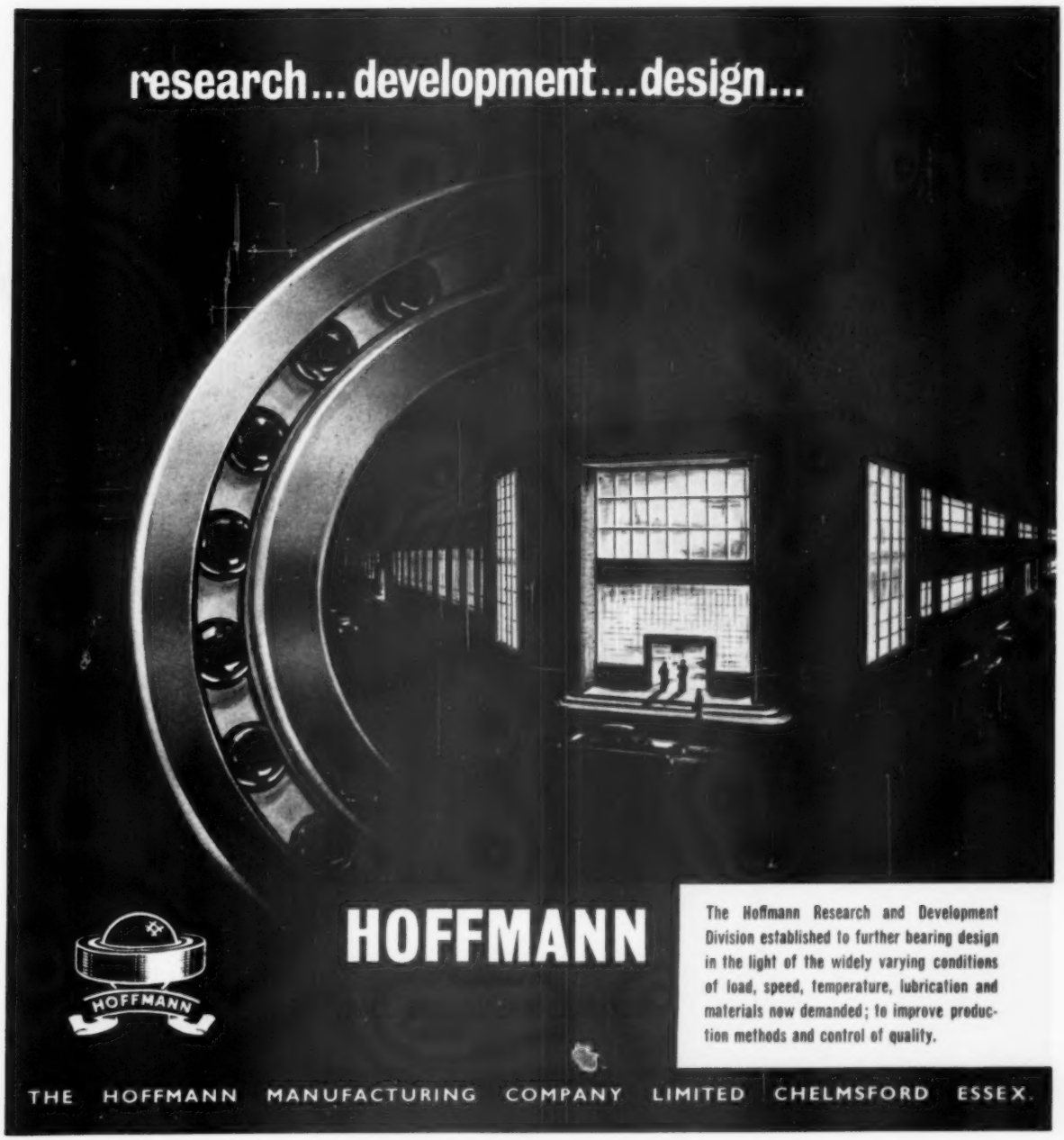
# AUTOMOBILE ENGINEER

DESIGN · PRODUCTION · MATERIALS

Vol. 50 No. 9 SEPTEMBER 1960 PRICE: 3s. 6d.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*The Ecco 40 is easy to maintain. The streamlined design hinders paint from congealing on the exterior; as there are few parts, stripping and cleaning are swift and simple. Teflon packings are used to prevent paint leakage.*

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**puts compressed air to work for the world**

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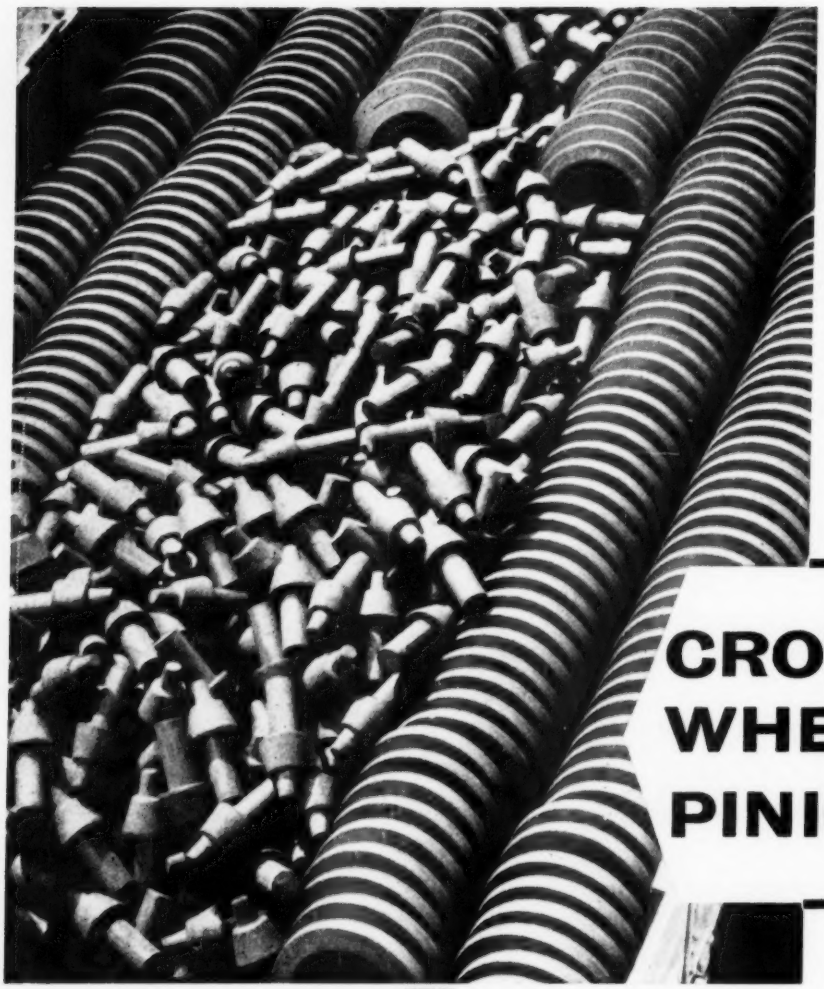

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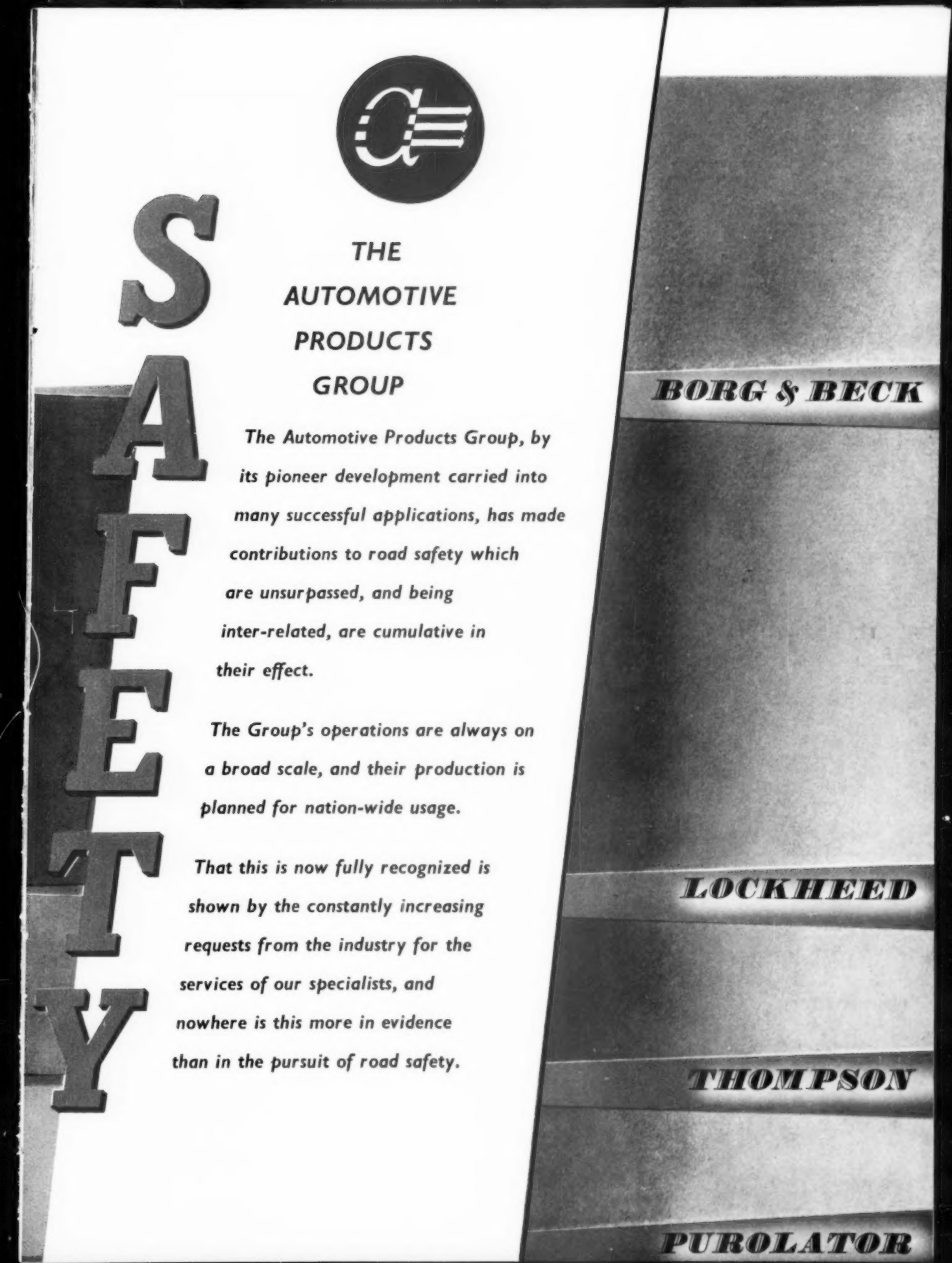
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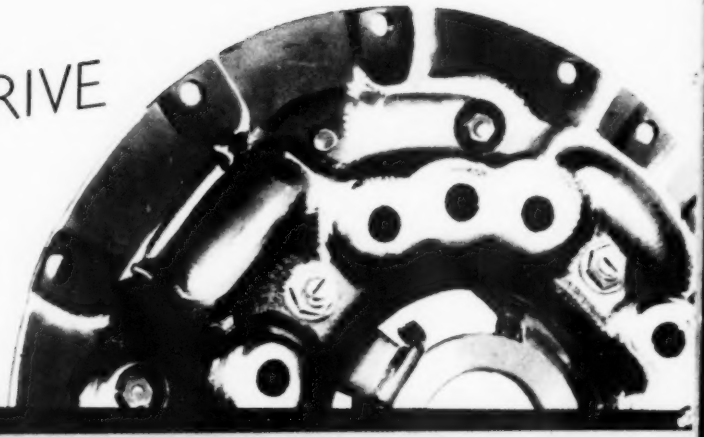

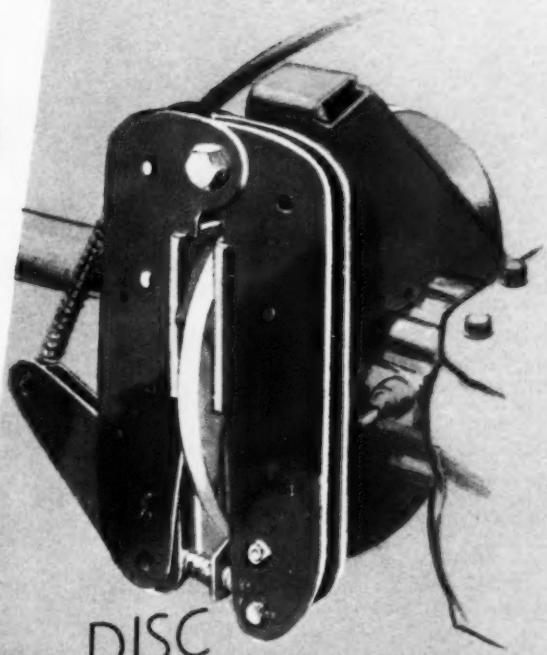

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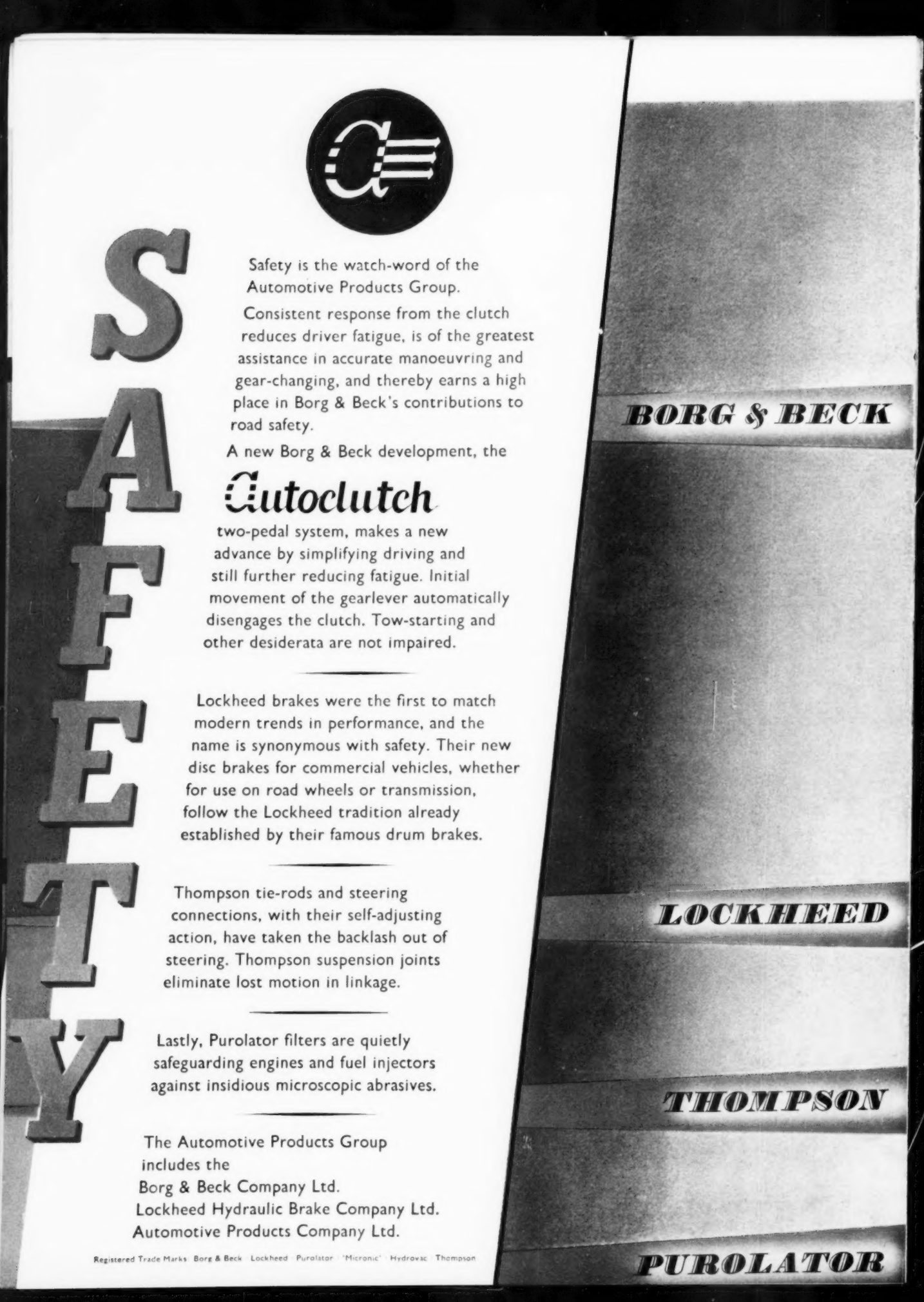


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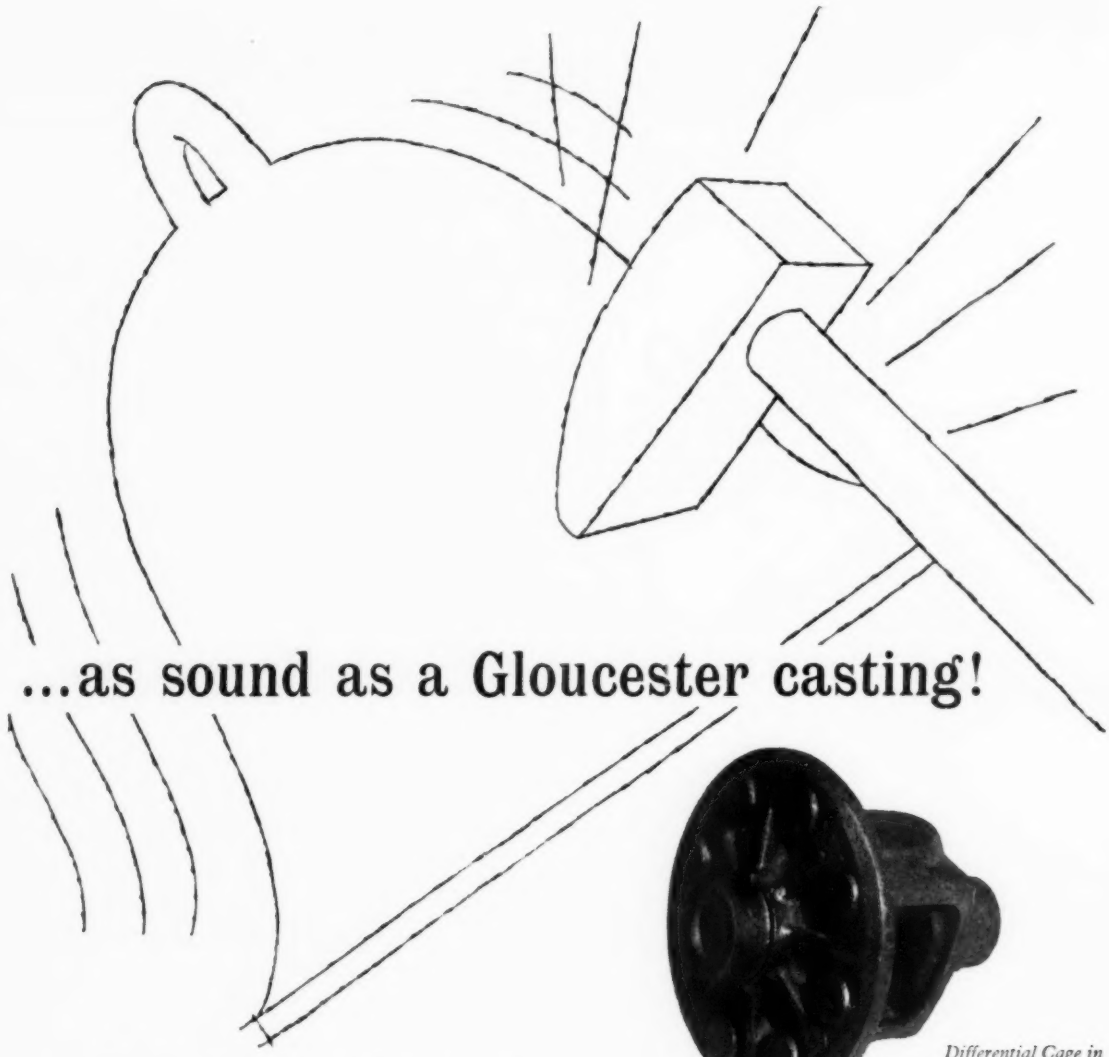

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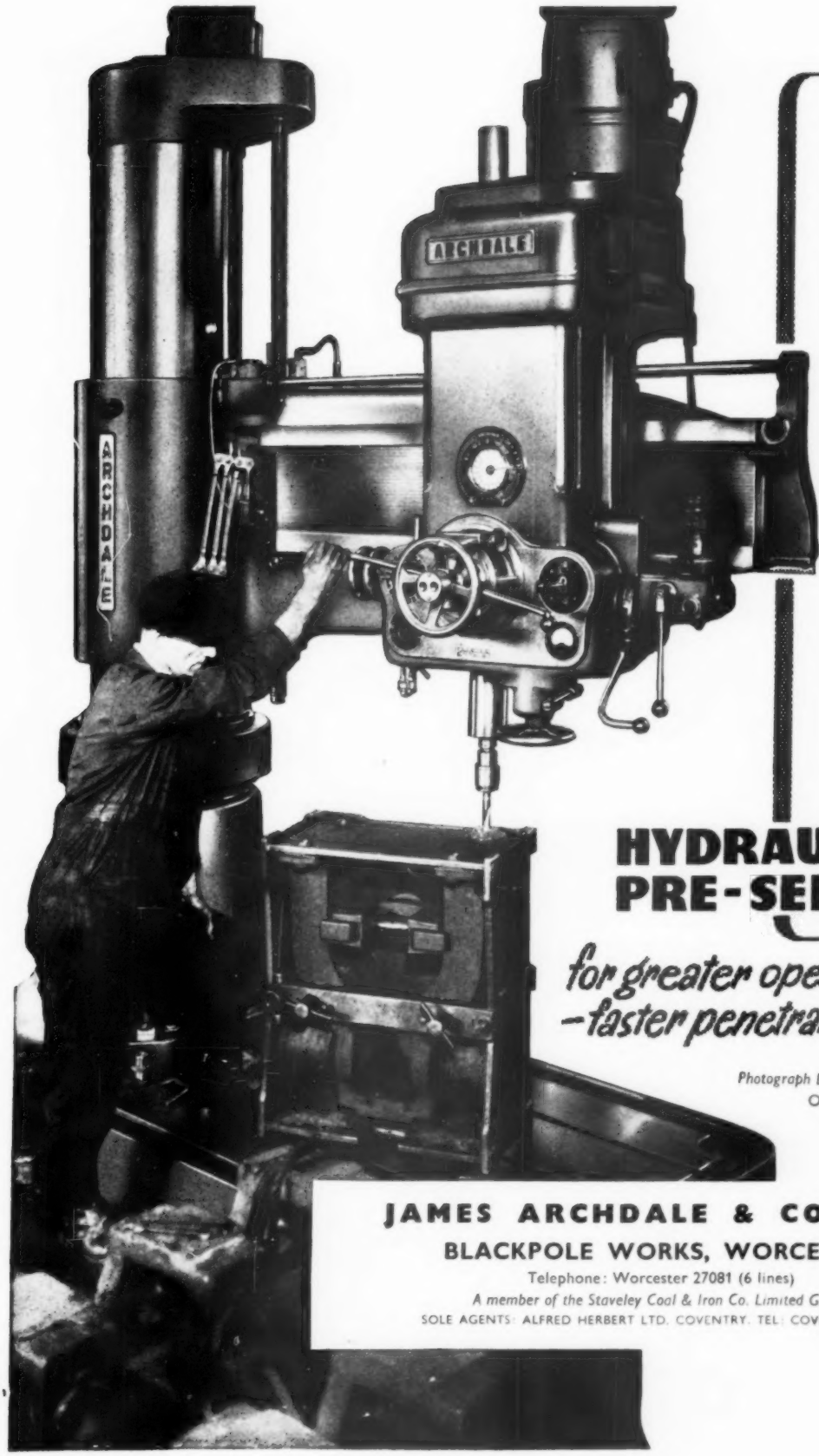


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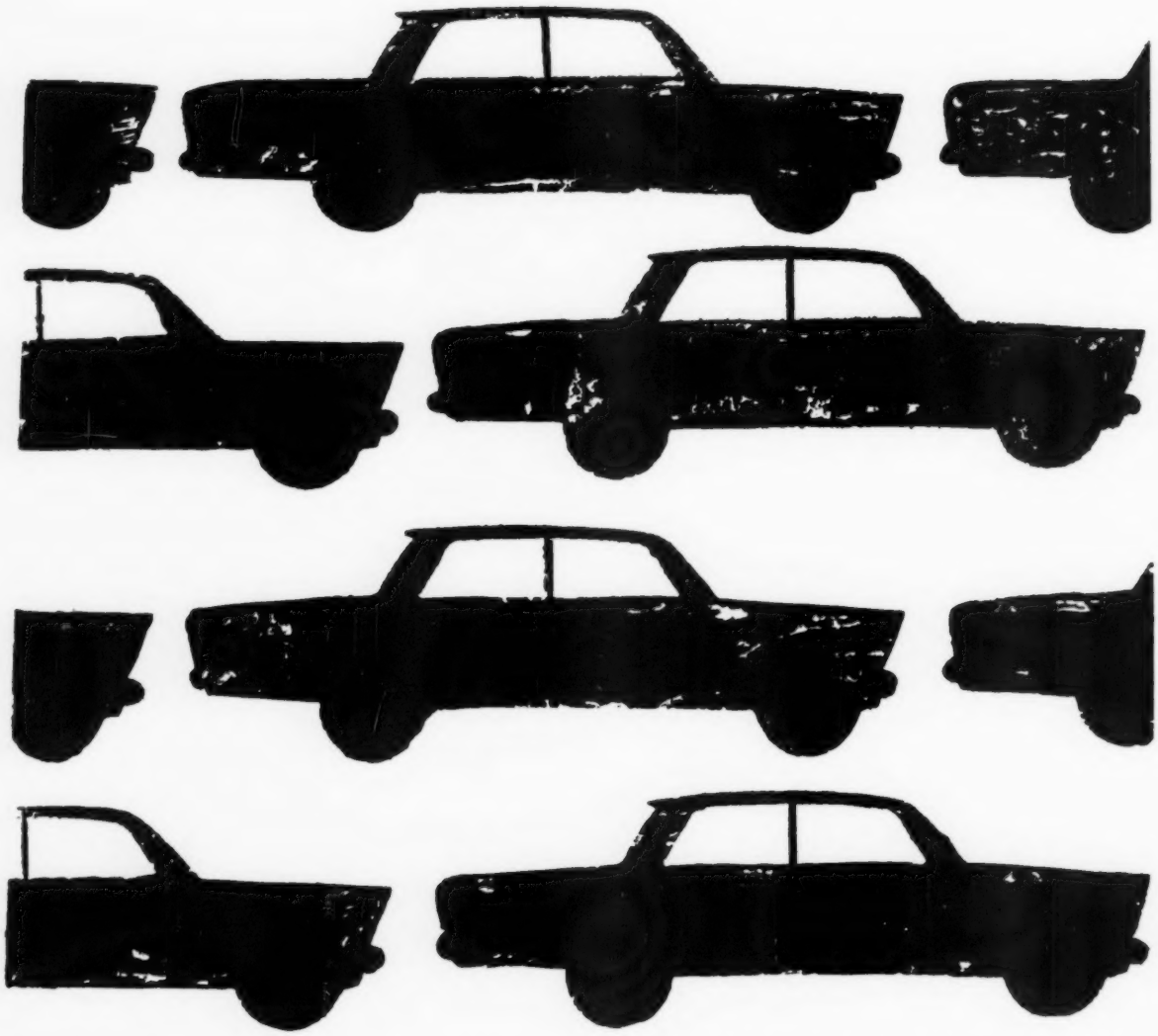

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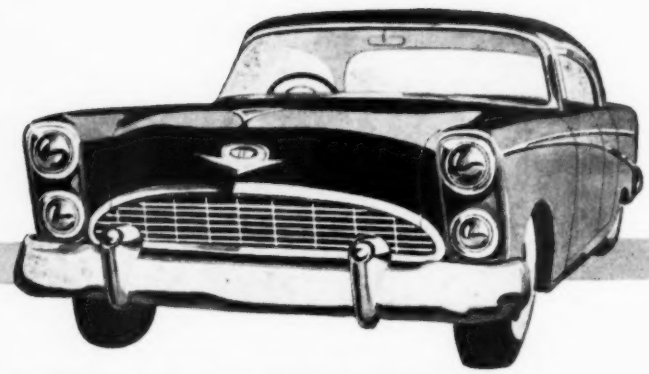

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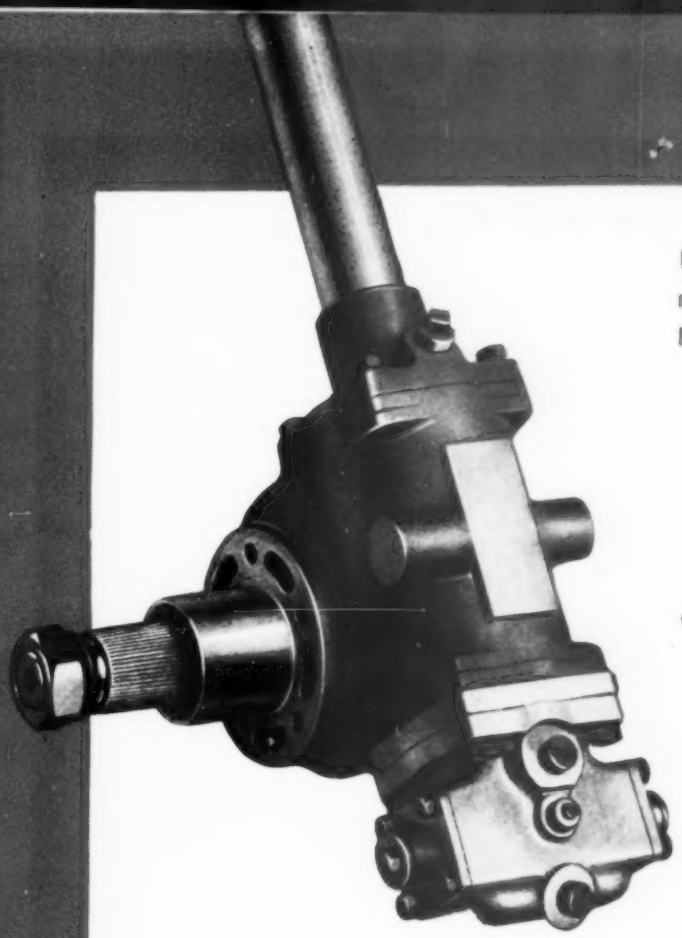

Interchangeable, on the same mounting, with the standard Marles manual gear unit.

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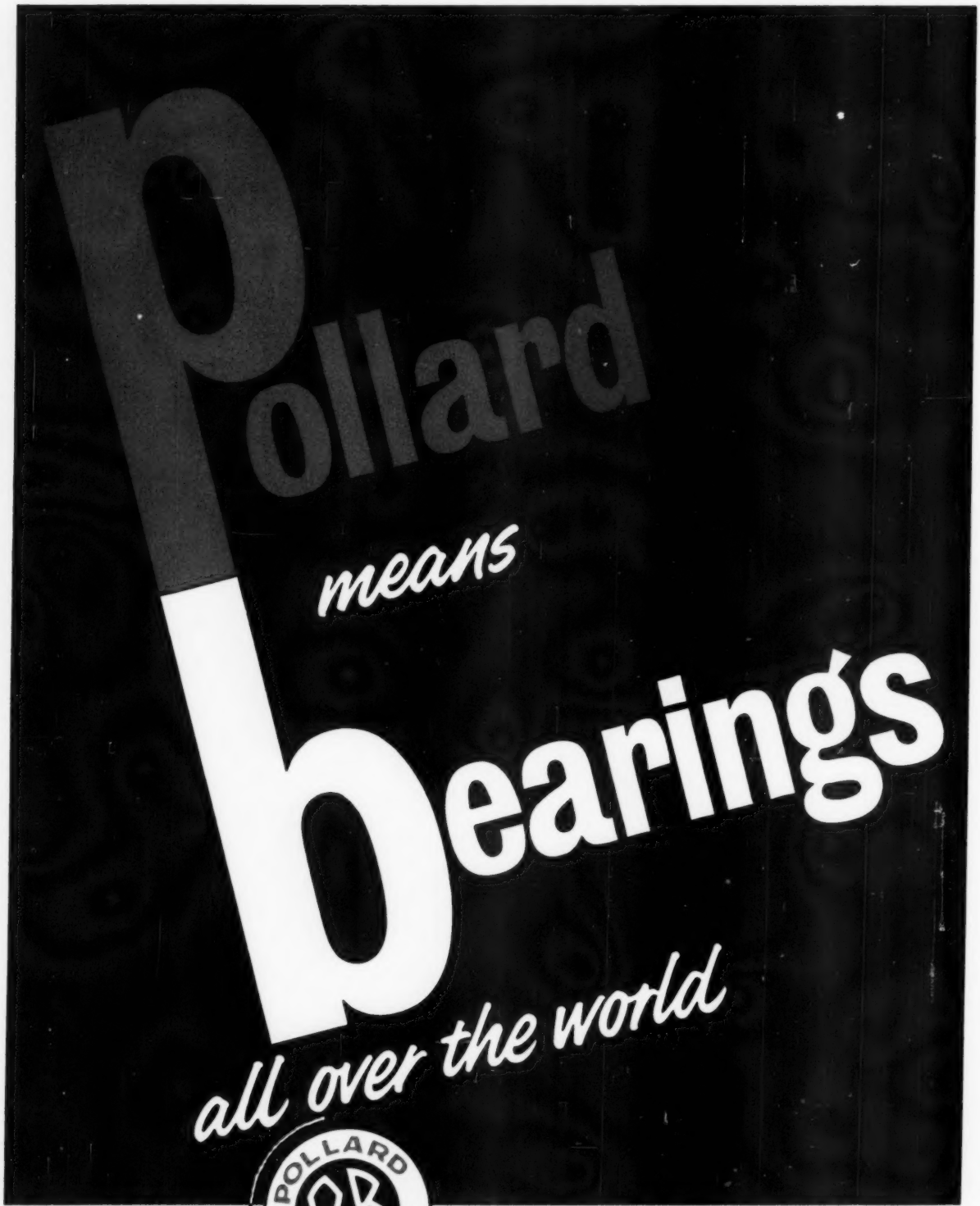


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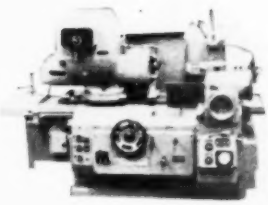

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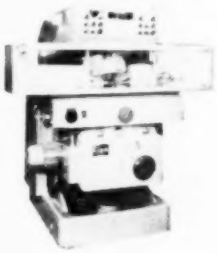

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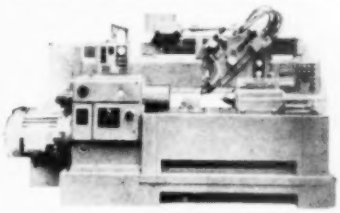

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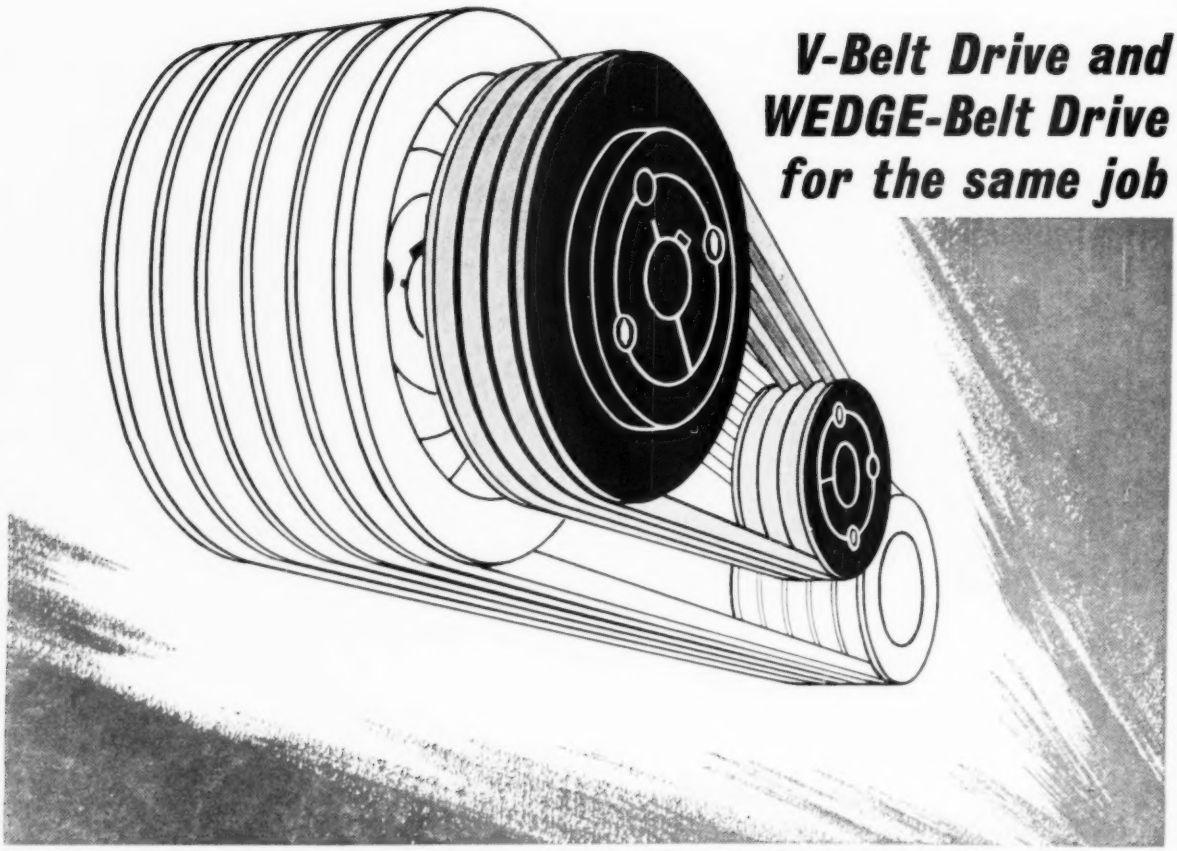

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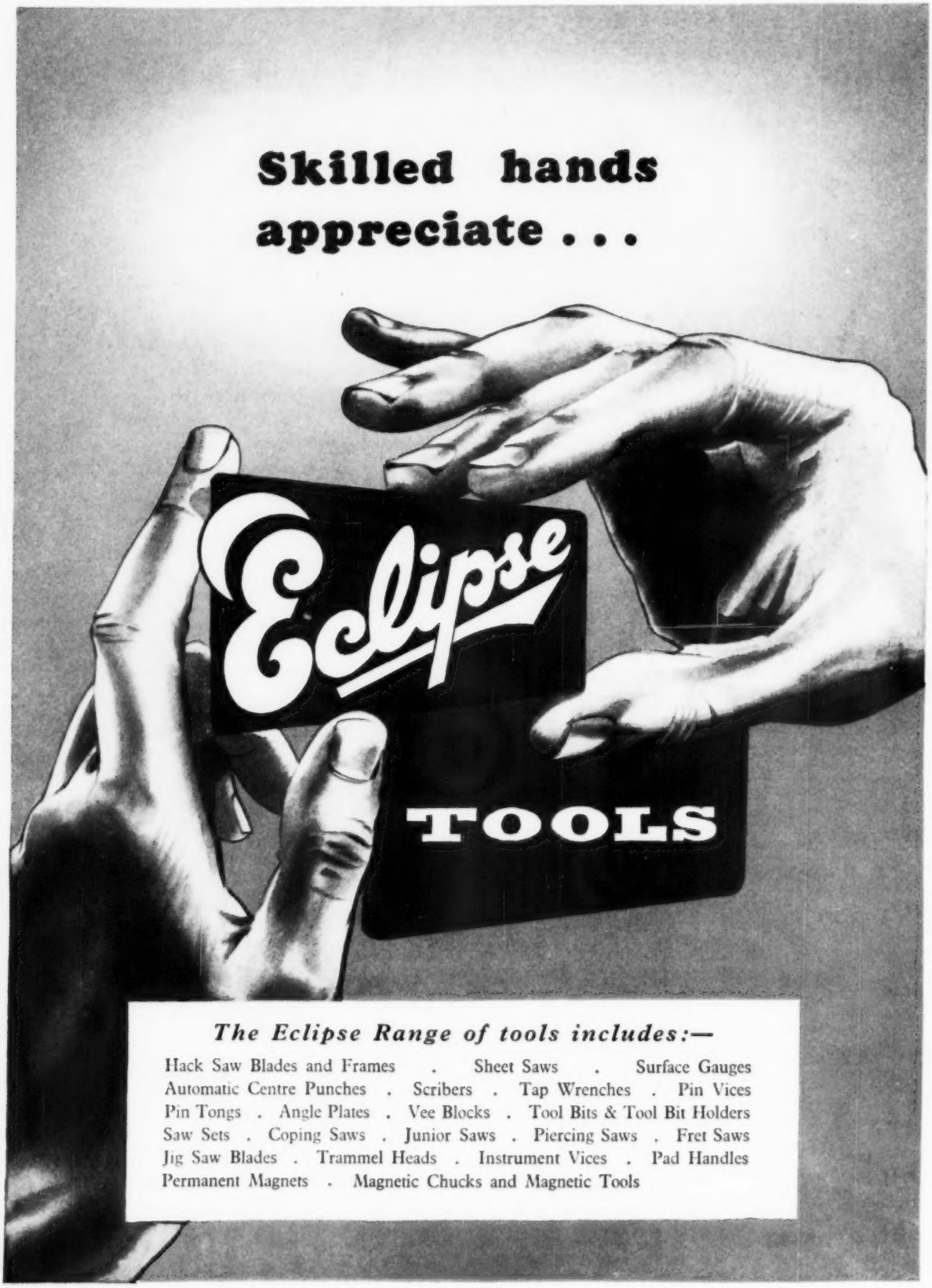


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UX13

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## WITH DU PONT ELASTOMERS

**Ozone is present in the atmosphere, generated from Oxygen in the air by ultraviolet light (from sunlight). When natural rubber is stressed, as in car components, ozone attacks, forming a myriad of small cracks in the surface of the rubber.**

DU PONT NEOPRENE has outstanding resistance to ozone cracking. Du Pont neoprene has proved under test, and on the job, that it is vastly superior to natural rubber—and to "general purpose" synthetics. Neoprene resists oil and grease in the chassis . . . high temperatures under the bonnet . . . oxidization and aging of exposed parts and accessories. Properly compounded neoprene products meet most service needs at temperatures ranging from —54°C to as high as 121°C. Compounds can be made soft or hard and in sponge form. HYPALON* synthetic rubber has even greater heat and ozone resistance and is known for its remarkable colour stability, permitting use of bright colours for weather stripping and convertible tops. Hypalon doesn't become brittle in cold weather nor will it crack under heat or summer sun.

*HYPALON IS DU PONT'S REGISTERED TRADEMARK FOR ONE OF ITS ELASTOMERS

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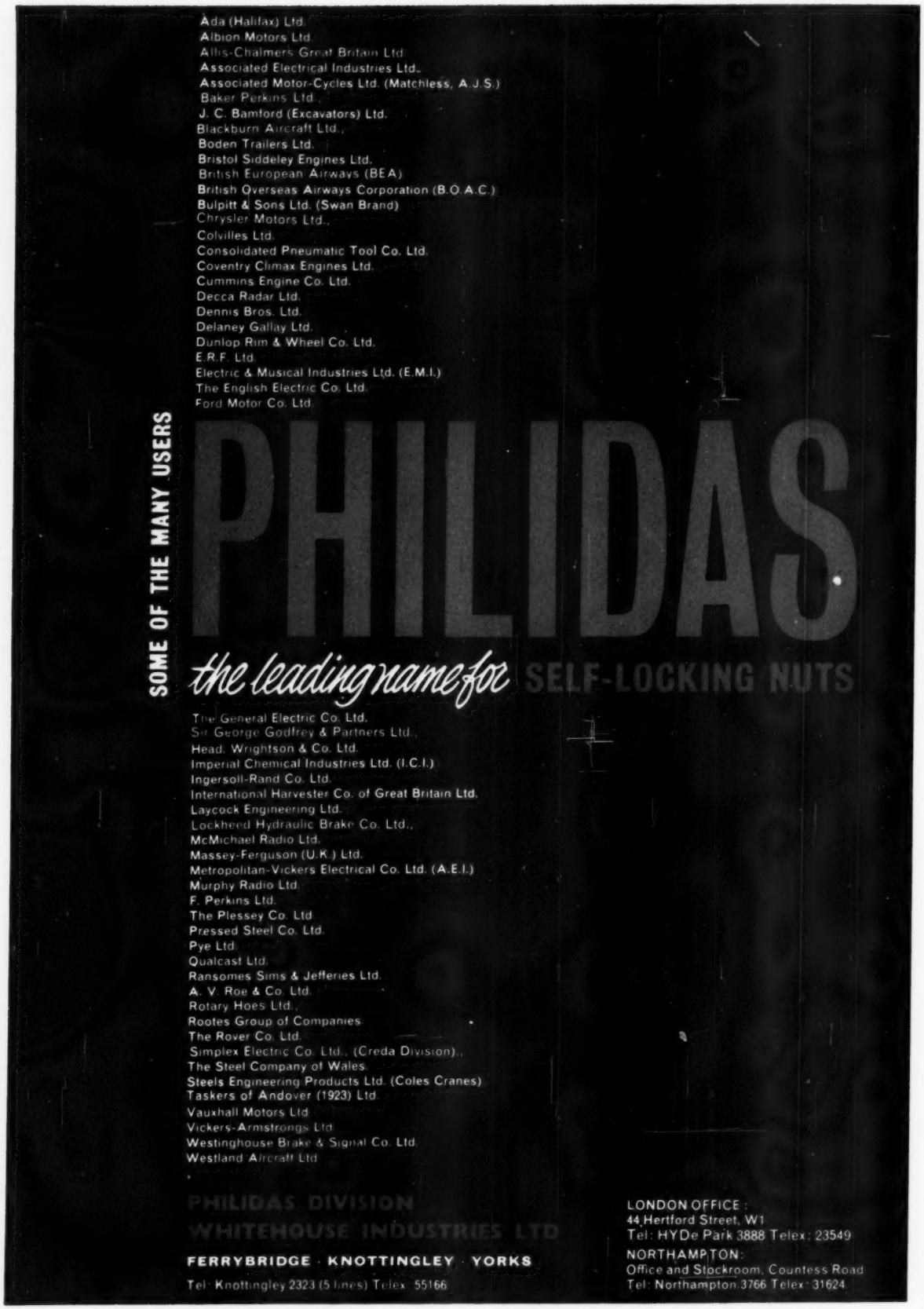
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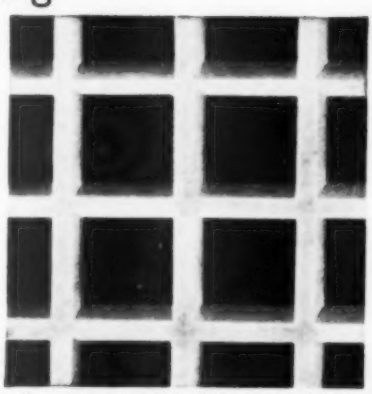
# for heat resistance

## special "thin-flash" type for grille moulding

Beetle D.M.C. is the material used for the grille of the Morphy-Richards Fan Heater because it offers high heat resistance and good appearance. The use of D.M.C. posed a flash-removal problem in relation to the many apertures, as the moulders, Crystalate (Mouldings) Ltd., specified a very thin flash line. Accordingly, B.I.P. Chemicals Ltd. developed a special type of material (D.M.C. L.1834) which, in combination with a tool made to close limits, ensures a consistently thin and easily removed flash.

Beetle D.M.C. combines heat resistance with strength, dimensional stability and excellent insulation properties. The development of a special type for a single application typifies the extent of B.I.P. services in relation to individual problems and requirements.



*Heat resistance, dimensional stability, strength and electrical insulation properties are among the features making D.M.C. the ideal material for this grille. Moulding by Crystalate (Mouldings) Ltd., Tunbridge, Kent.*

**BEETLE***

**Polyester dough moulding compound**

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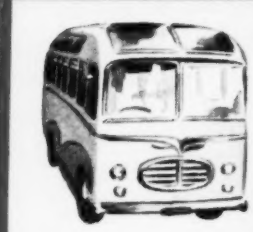

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Obviously the shrewd men who control such a thriving concern have a flair for making long-term decisions that are both wise and profitable.

Raleigh use coal because all their experience has proved that coal gives them all the steam for both power and heat they need at the lowest possible cost. Raleigh are *expanding* on coal because they know that our coalfields contain all the coal that industry can use for many scores of years to come.

# *cycle at Raleigh*

When it is your turn to cast a vote on fuel, remember Raleigh. Coal is the power that starts their wheels spinning so profitably. You can make *sure* that the wheels of your industry do the same for you when you stake your future power on the most reliable of all fuels—coal.

***PROGRESSIVE INDUSTRY***

***IS GOING FORWARD ON***

# COAL

## Policy into practice at Raleigh Industries

***Mr. L. L. Roberts,***
***Director of Factories, comments:***

"Coal is the fuel chosen for the whole of Raleigh's power-raising plant, including our newest installation which comprises four horizontal economic boilers. These operate on ½" washed smalls, and have a combined total rating of 74,400 lbs. of steam output per hour from and at 212°F.

An overall average efficiency of 72-75% can be easily maintained, although under test conditions we have recorded efficiencies of 80%.

All our coal handling plant is fully mechanised and apart from periodical trimming of the receiving bunkers, the fuel doesn't have to be touched at all by our boilermen anywhere from the delivery bays to the firebeds. After burning, the ash residue is automatically conveyed to overhead storage bunkers outside the boilerhouses, from where it is easily discharged into lorries for disposal.

Our emergency stocks of coal are relatively small. We prefer to operate on a direct supply basis from colliery to boilerhouse for more or less immediate use. This would not suit every firm, but in our special circumstances I am perfectly satisfied that deliveries are reliable enough to make this system dependable, and the possibility of an emergency arising out of failure of supply is very remote. We have operated this way for three years now without any trouble at all and will continue to do so in the future.

Raleigh's decision to use coal is based on economics. We want maximum reliability at the lowest possible cost—and I'm happy to say that with coal that's exactly what we get."

***And here are some key facts and figures about the No. 1 Boiler House (Orston Drive)***

**Boilers:** ..... 4 Horizontal Economic boilers
**Total capacity** ... 74,400 lbs. of steam per hour
**Method of firing** ..... Chain grate stokers
**Steam pressure** ..... 80 p.s.i.
**Steam temperature** ..... 324°F.
**Annual fuel consumption** (*all boilerhouses*):
22,300 tons of coal

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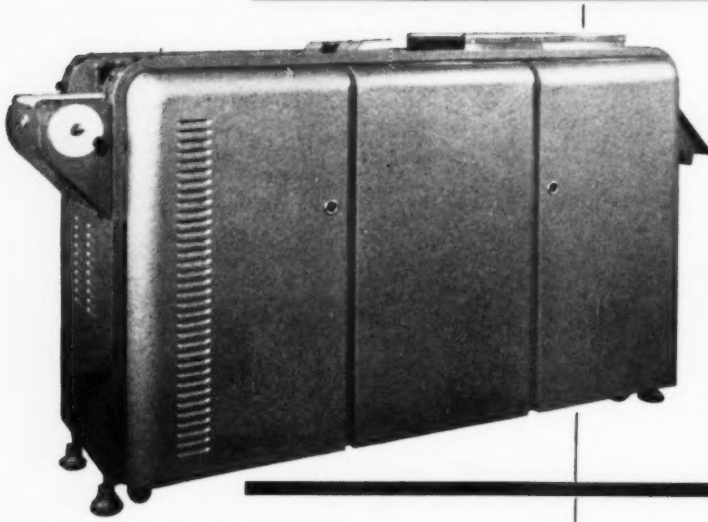
# AZOFLEX FB Intense-line Paper in a

# Model 150 AZOFLEX Dyeline Machine

AZOFLEX is the word for fast, economical photoprinting. Using AZOFLEX FB intense-line paper, you can get 10,000 copies of invoices, documents, parts-lists, etc., every working day from the Model 150 AZOFLEX combined automatic printer/developer. Consider these major economies:



**1**

AZOFLEX FB dyeline paper supplied in rolls is $\frac{2}{3}$ cheaper than cut sheets. SAVING: approximately £1,800 per annum on output of 10,000 (13″ × 8″) dyeline prints per day.

**2**

Output of only one Model 150 with one operator is the equivalent of four machines hand-fed by four operators. SAVING: approximately £1,100,

**N.B.** Many business and industrial concerns find that it pays them to hire certain AZOFLEX dyeline machines, rather than buy them outright. Alternatively, rental purchase may be preferred.
May we send a representative to discuss in confidence the most beneficial terms for your company?

Even if your requirements are only 5,000 copies a day, your total annual saving can amount to £1,000 per annum, and leave your AZOFLEX operator time for other duties. AZOFLEX dyeline reproduction saves time, saves space, saves staff, and saves real money.

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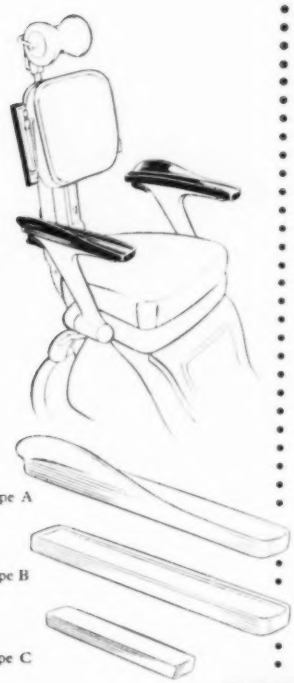

*Shown by courtesy of Amalgamated Dental Engineering Industries Limited*

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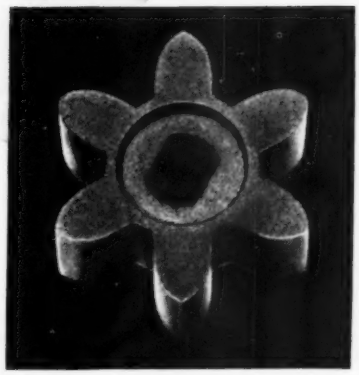

*Our Technical Department is readily available for consultation*

**Bound Brook Bearings Limited**

Trent Valley Trading Estate, Lichfield, Staffordshire.
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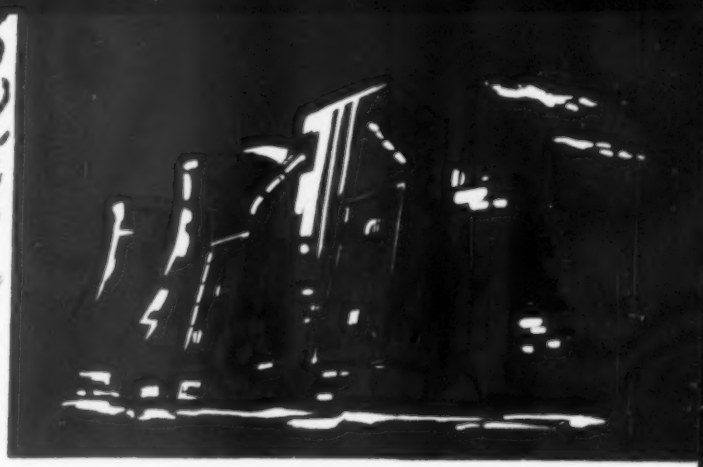

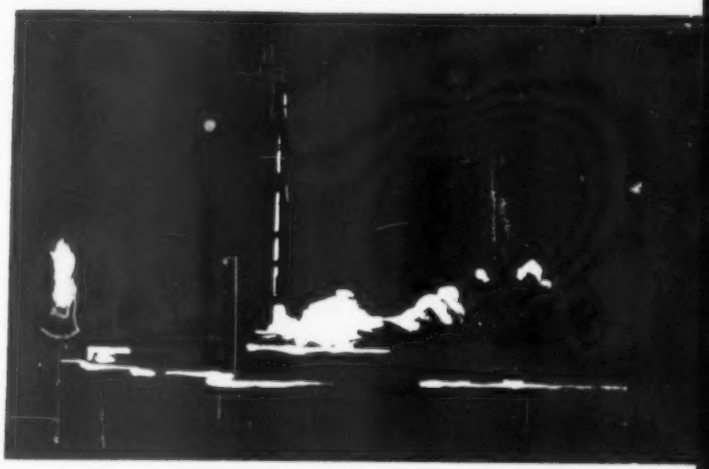

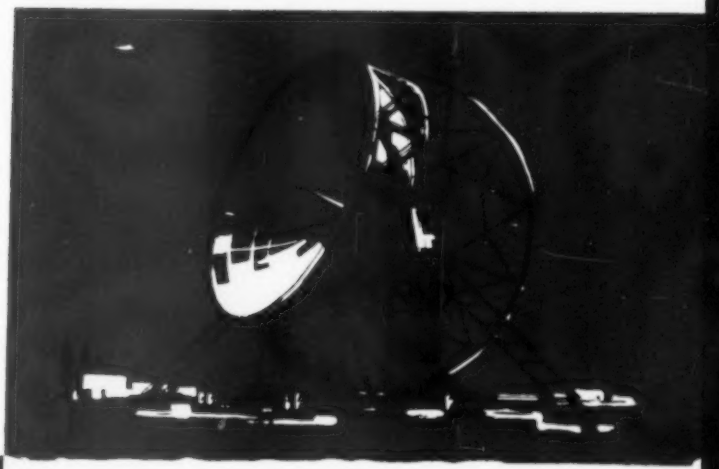

New projects of science and industry,
improved methods of production and
new materials to be worked,
have brought a challenge—
a challenge to provide cutting tools
equal to these new demands.
A challenge met by DORMER.
Our experience, technical knowledge
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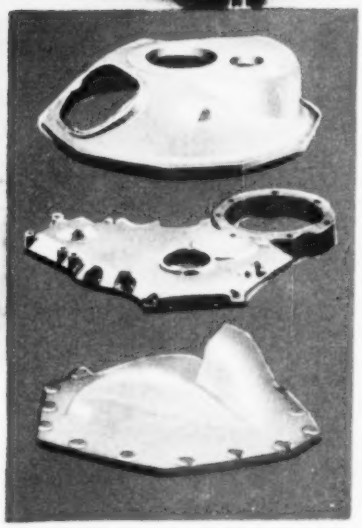
## WEIGHT AND COSTS



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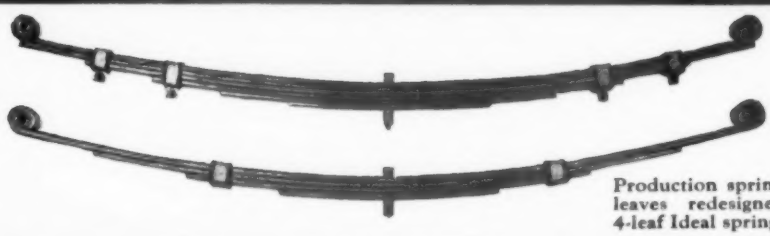
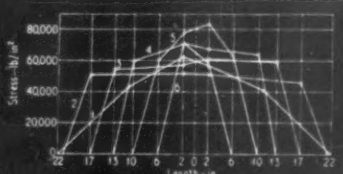
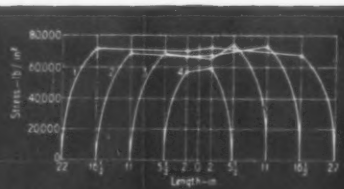
CAST WELL AND TRUE

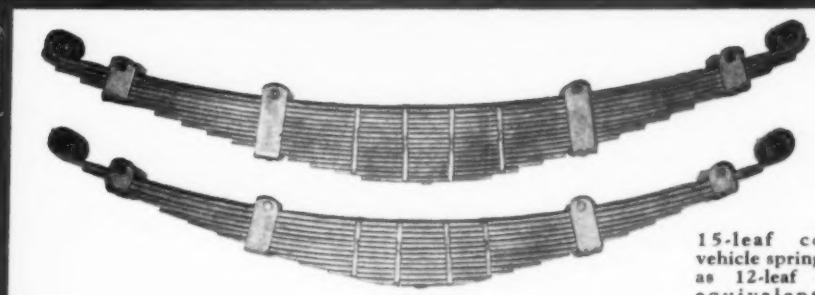
# HOW TO SAVE SPRING WEIGHT WITHOUT INCREASING STRESS



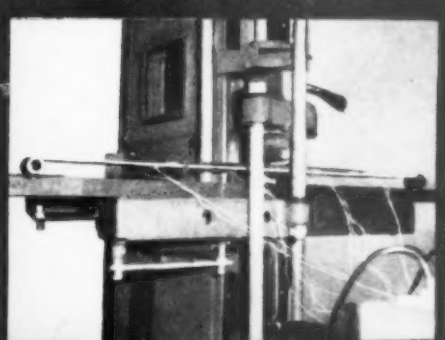
Production spring with 6 leaves redesigned as a 4-leaf Ideal spring.



15-leaf commercial vehicle spring redesigned as 12-leaf Featherlight equivalent without increase in maximum stress.



**TWS**
**'featherlight'**
**IDEAL SPRING**
[PATENTS PENDING]

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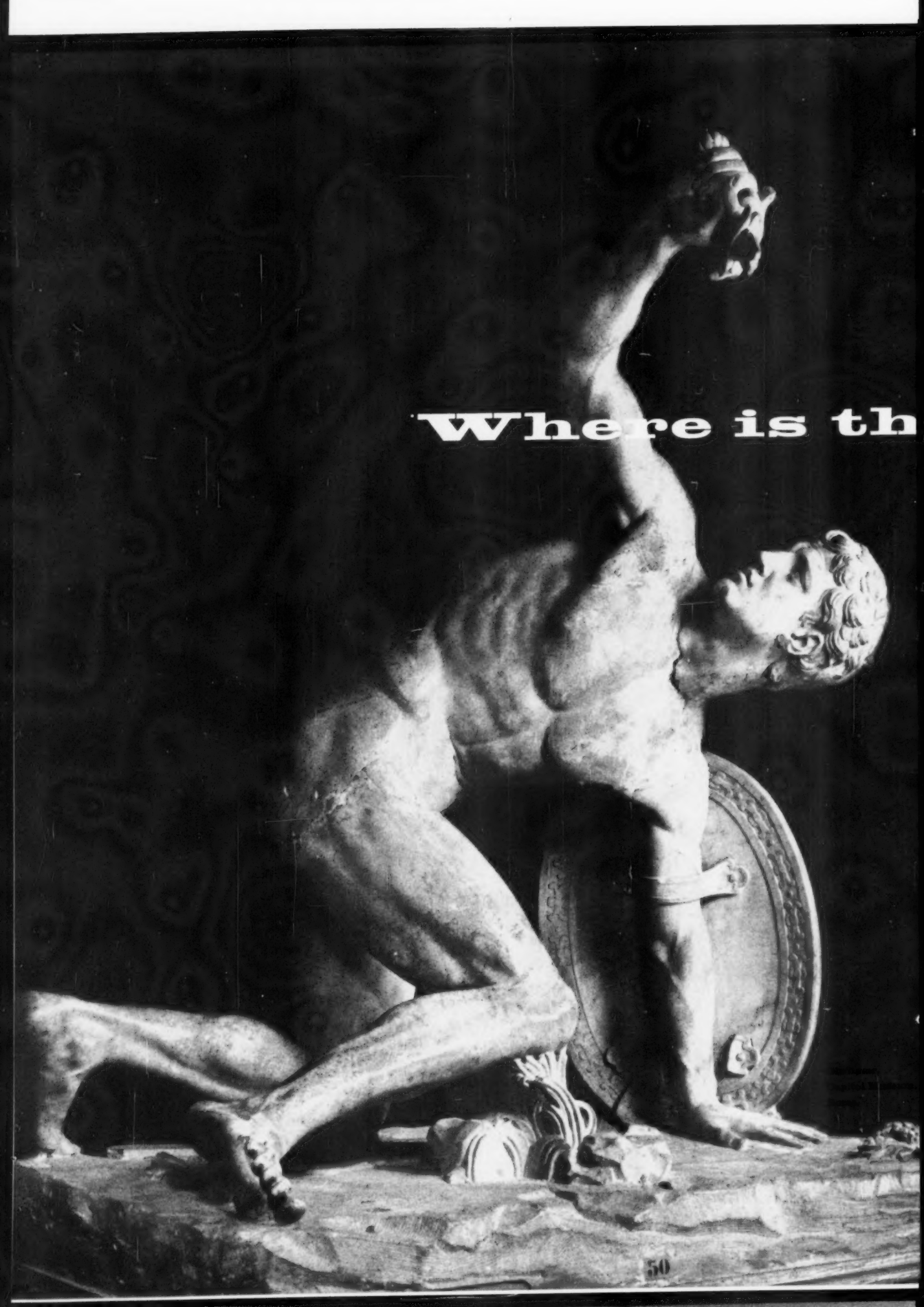
Where is th

# e point ?

There is no point in taking on a dozen competing firms all pushing different pieces of finishing equipment. A mass of staff-consuming detail is involved tending to obscure the overall picture of a complete finishing system. That is why many manufacturers with large-scale finishing problems have now scrapped the old piecemeal approach to product finishing. Instead they delegate the whole responsibility to a single specialist organisation with no axes to grind — Lysaght-DeVilbiss.

This organisation designs, manufactures and installs complete product finishing systems from metal pre-treatment to final stoving. With their horizon broadened and skill refined by over fifty years of specialisation, Lysaght-DeVilbiss can offer unbiased advice on the surface coating system best suited to your product.

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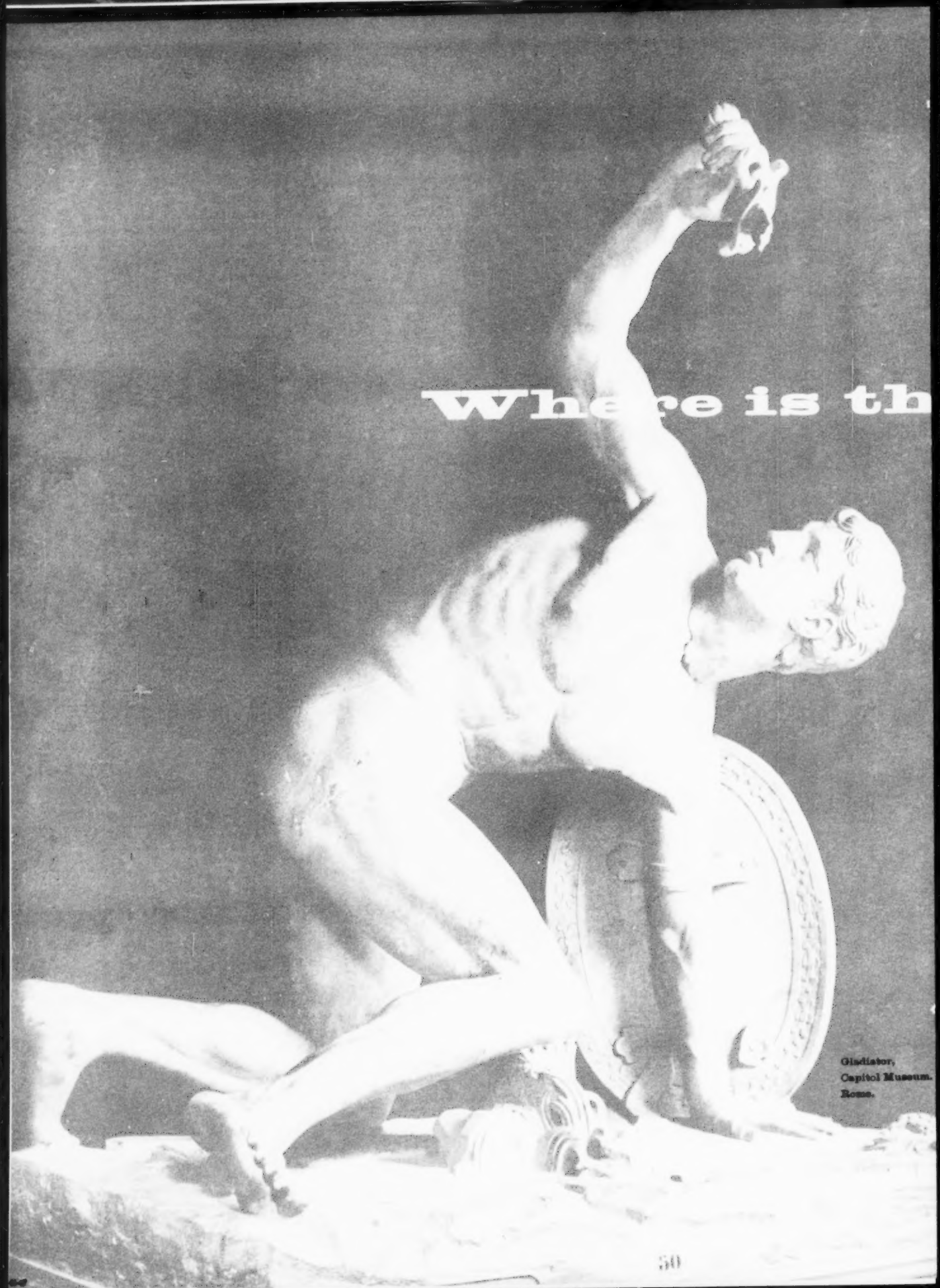


Gladiator,
Capitol Museum.
Rome.

# e point ?

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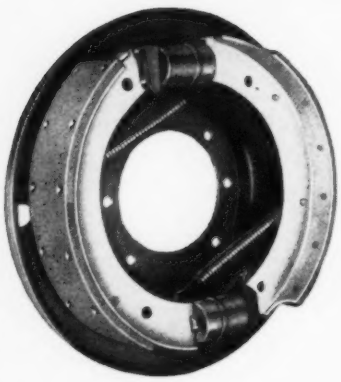
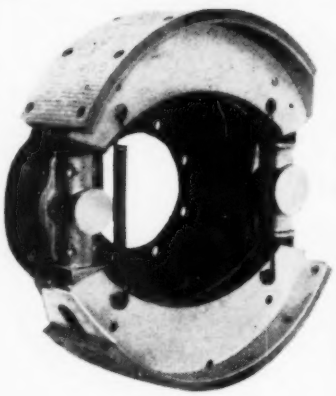
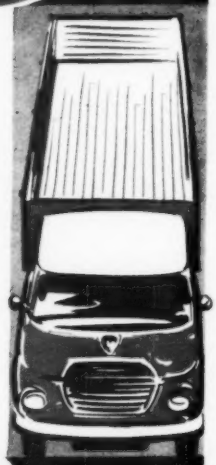
# GIRLING







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It's significant that the majority of British Commercial Vehicles are fitted with Girling Braking systems — significant but not surprising, because Girling have all the experience of 30 years, all the knowledge of an unremitting programme of research and development, and all the resources of the largest organisation of its kind in Europe to ensure that they do indeed make the Best Brakes in the World.

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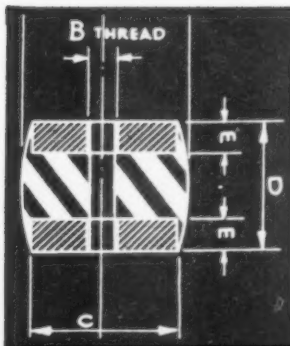


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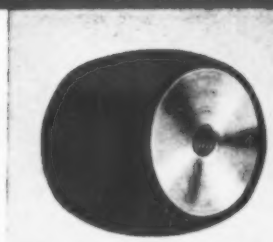

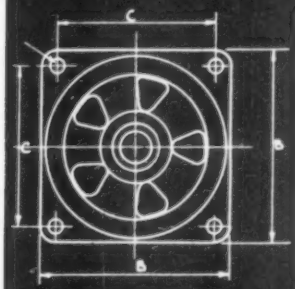


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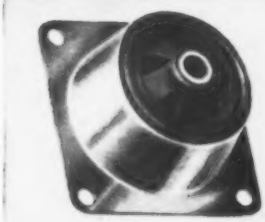

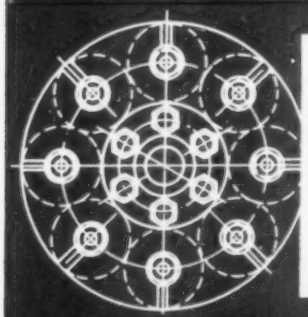

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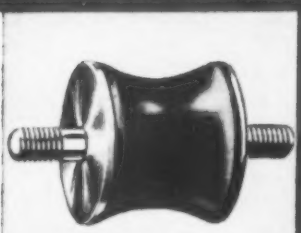

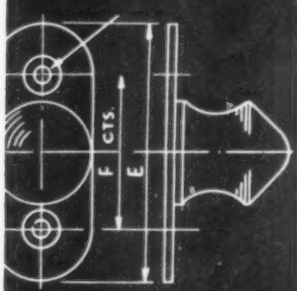


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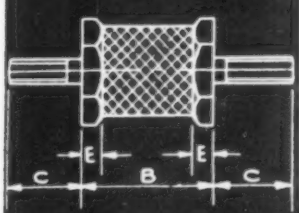


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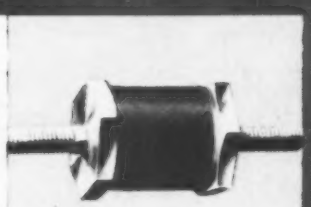

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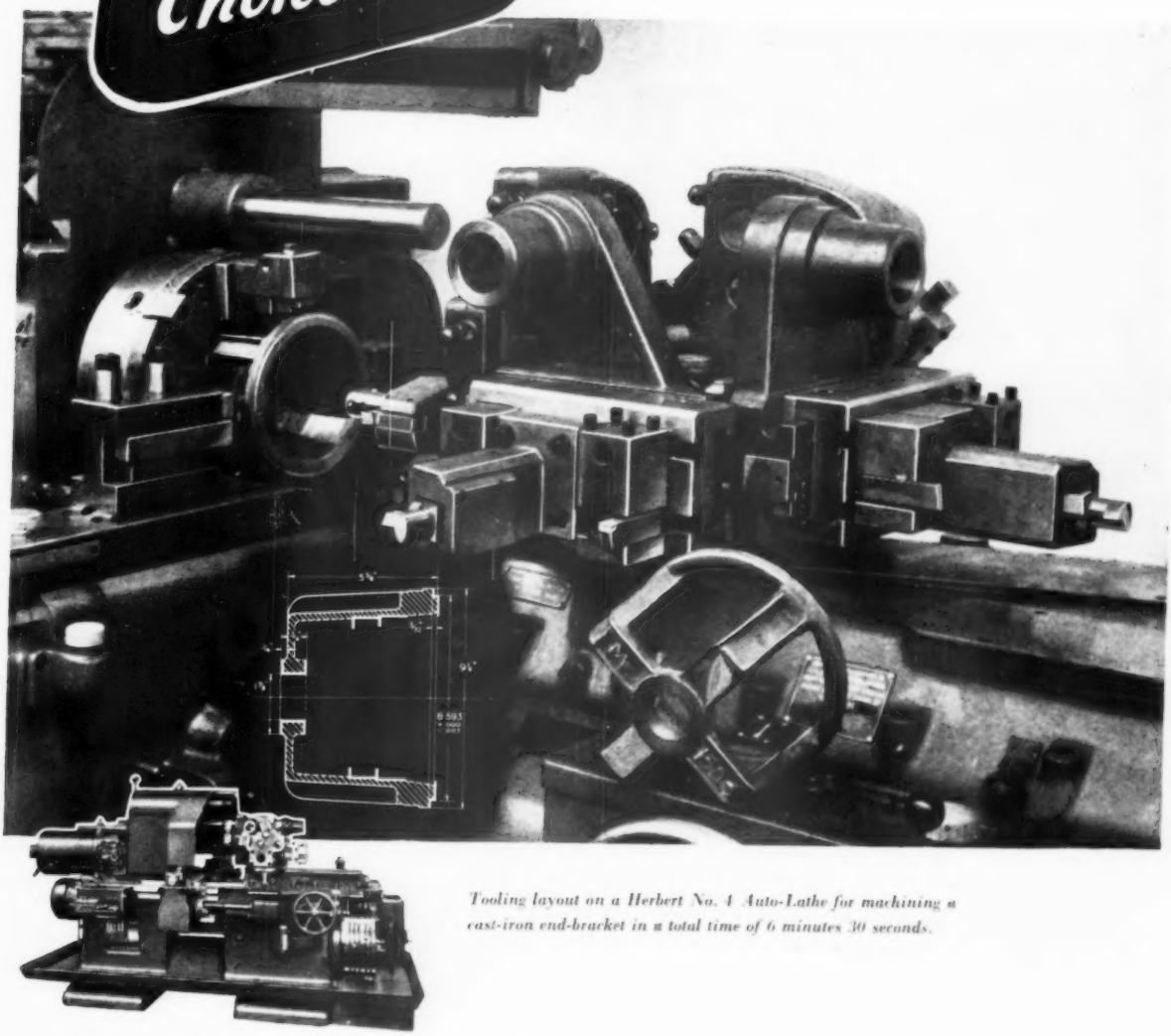

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**For high-production repetition work with consistent accuracy.**
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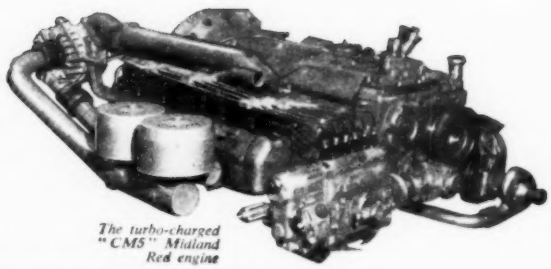

*The turbo-charged "CM5" Midland Red engine*

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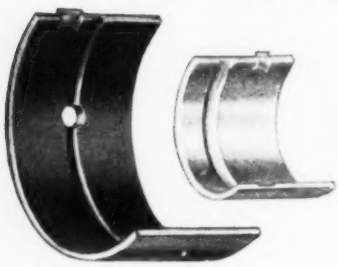

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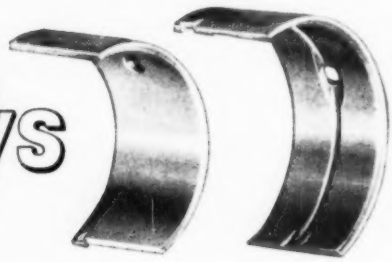

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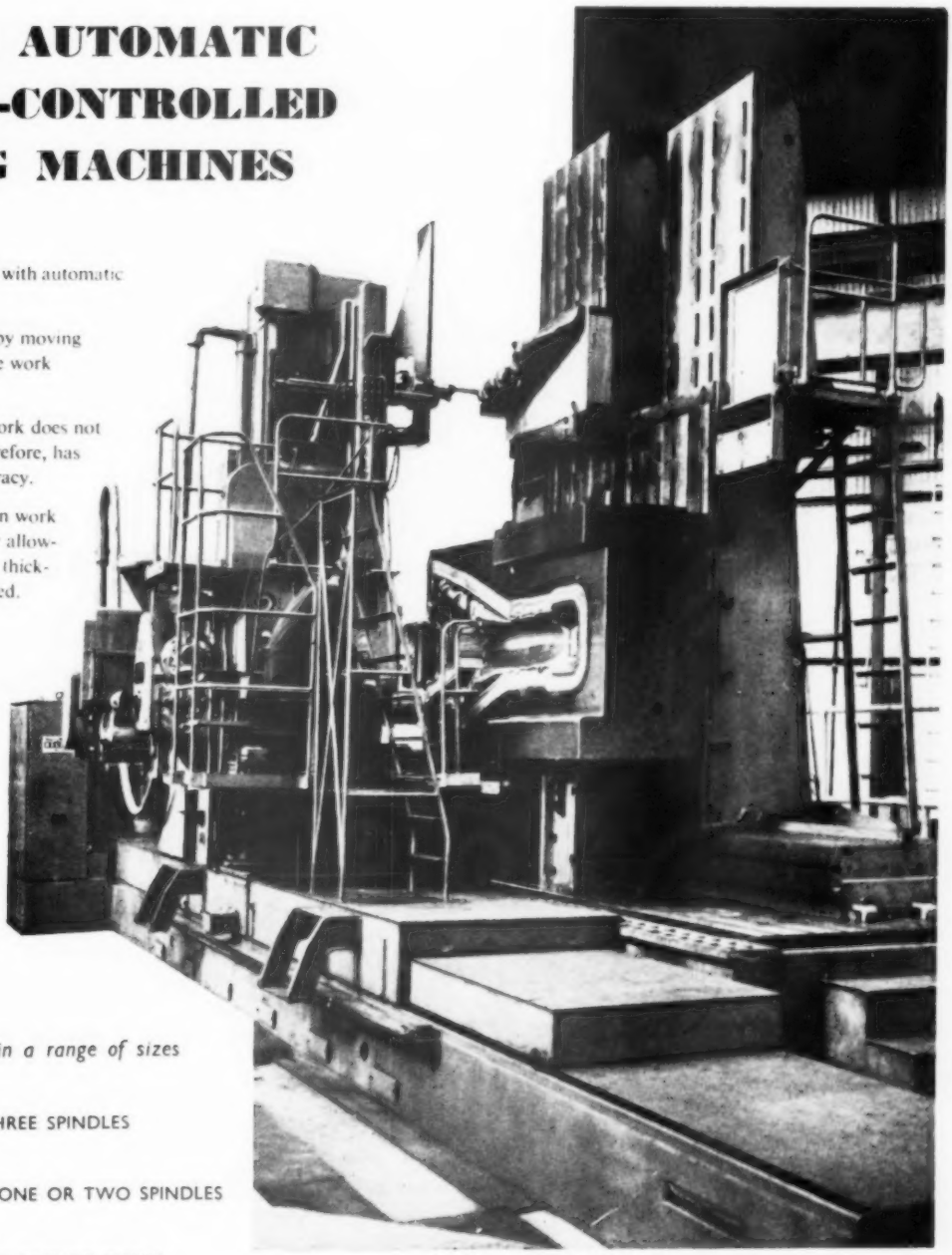

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*A Keller BG-22 Machine installed in the Forging Division of High Duty Alloys Limited, Redditch. This set-up shows the machining of a die for producing part of an aeroplane undercarriage component. The die blocks used for the forging of this component are of alloy steel and weigh 43 tons unmachined.*

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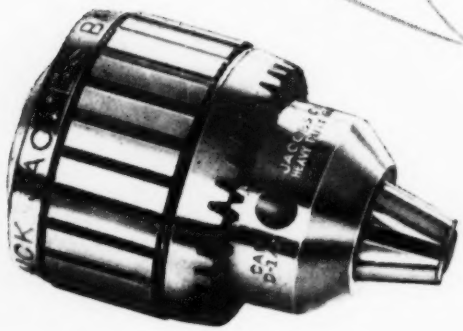

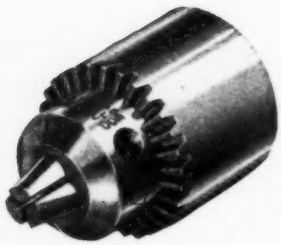

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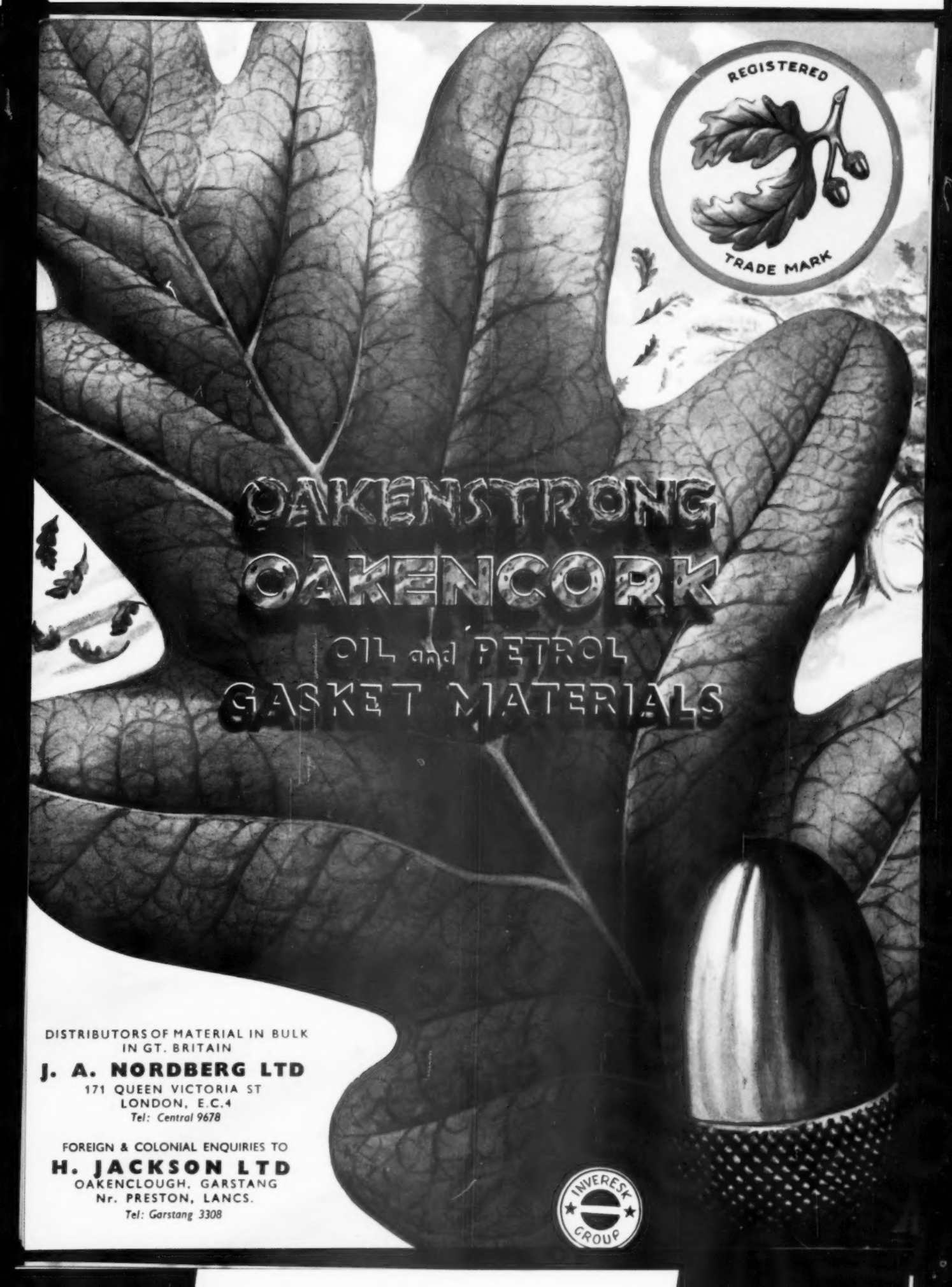


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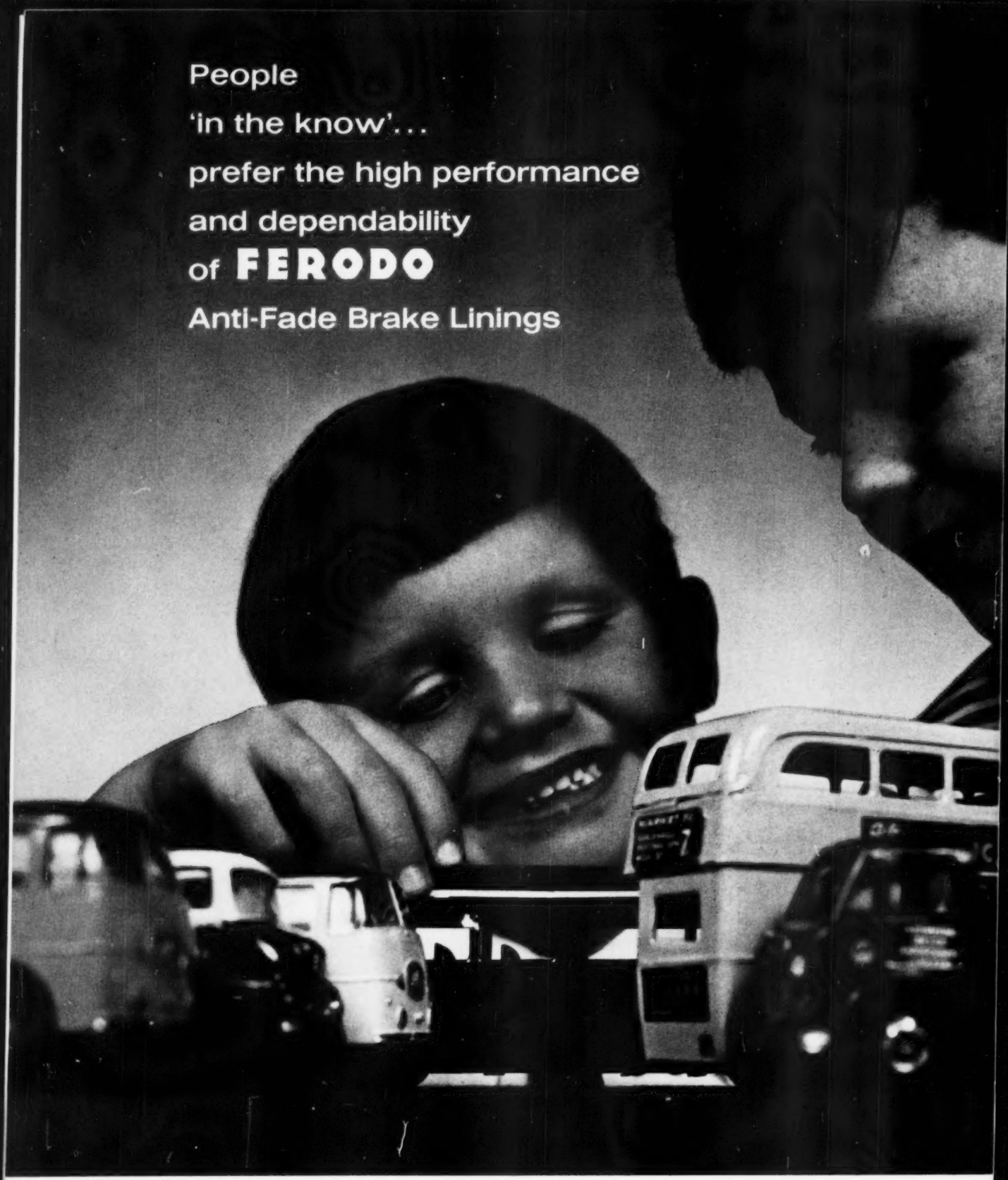


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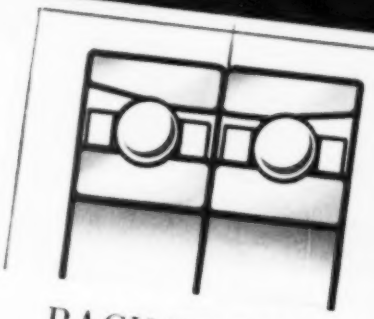


BACK-TO-BACK

*(VM)*

These FBC bearings were originally developed for use in high-speed machine tools; their use has since spread to instruments, turbines, compressors and other precision applications.

There are three precision grades—5, 7 and 9: in grade 5 the tolerances for the bore range from 2-ten thousandths of an inch* in the small sizes to 3-tenths in the large. The outside diameters range from 2-tenths tolerance in the small sizes to 5 in the largest, with corresponding accuracy in other dimensions. Grades 5 and 7 bearings meet the majority of precision applications but grade 9 bearings are also available for hypercritical uses.

For example, a grade 9 bearing of 30 mm bore has one-tenth tolerance in the bore and 1½-tenths in the O.D., one-tenth track eccentricity and track wobble; with parallelism tolerance on faces, and out of square of ½ a-tenth.

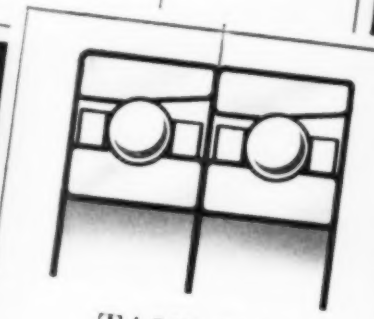
These bearings are generally used as follows, the standard bearings needing no selection for pairing:—

BACK-TO-BACK MOUNTING, giving greatest rigidity, automatically pre-loaded when locked up on shaft.

TANDEM PAIRING, as often used in high-speed precision grinding spindles, with one pair spring-loaded axially.

FACE-TO-FACE PAIRING, giving suitable pre-loading with outer races locked up.

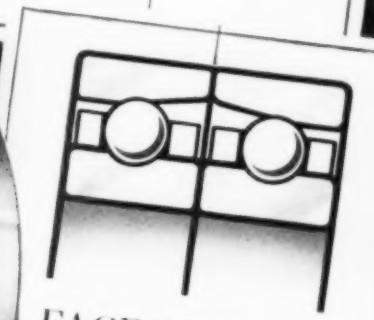
We are always ready to advise on the application of these and other FBC bearings, from our long and varied experience.



TANDEM

*(VF)*

** ½ a tenth: .001270 mm. 1½ tenths: .003810 mm. 2 tenths: .005080 mm. 3 tenths: .007620 mm. 5 tenths: .012700 mm.*



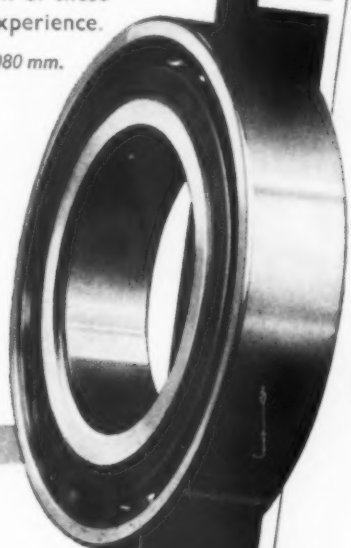
FACE-TO-FACE

*(VH)*

**F·B·C**

**BEARINGS**

*Regd. Trade Marks:* FAFNIR F·B·C FISCHER



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*(Successors to Fischer Bearings Company Ltd.)*

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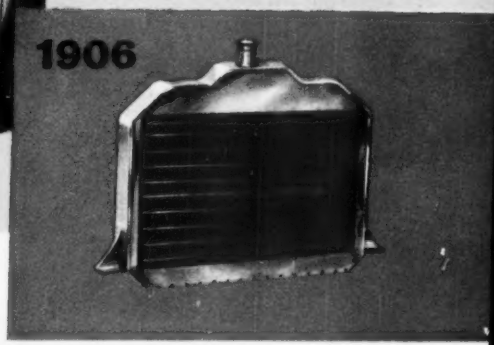


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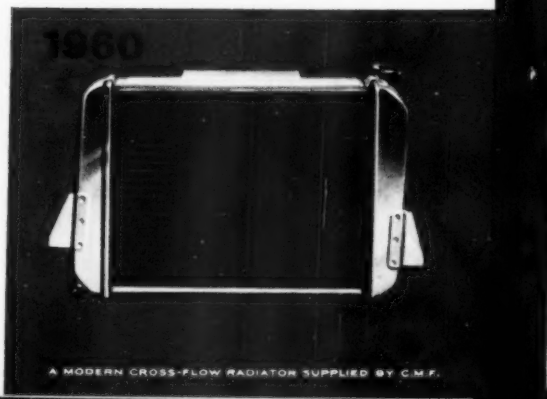
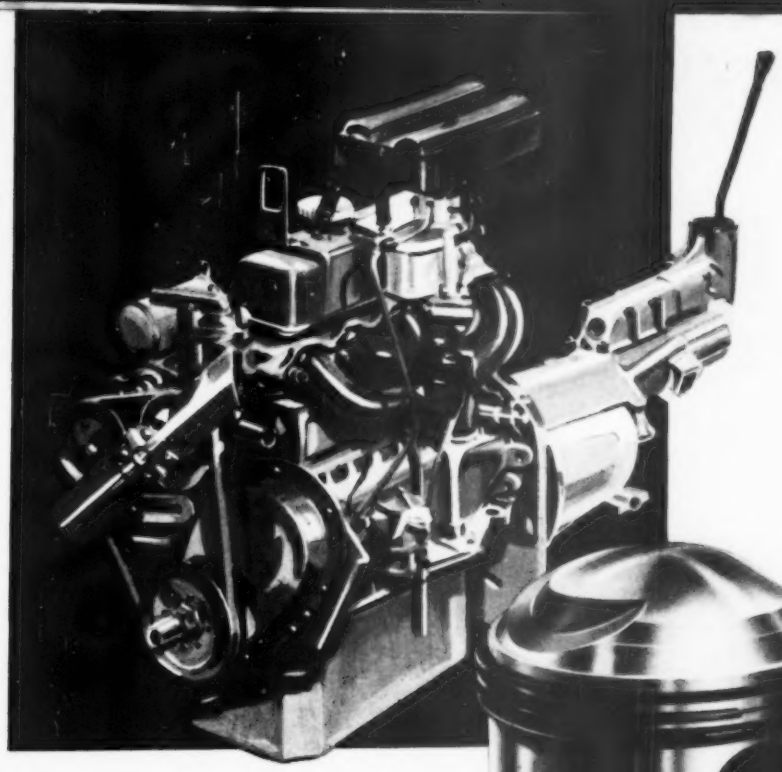
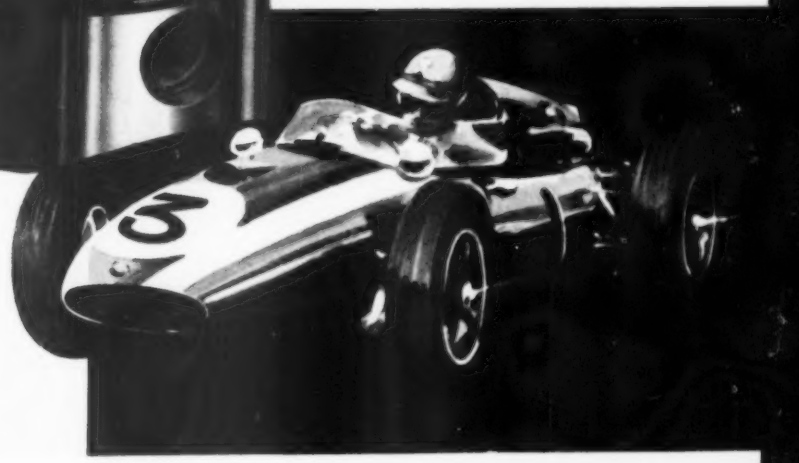



A MODERN CROSS-FLOW RADIATOR SUPPLIED BY C.M.F.



## PRODUCTION

BRICO make all the pistons for the famous "A" series engines for B.M.C. vehicles—the biggest piston job in the country.



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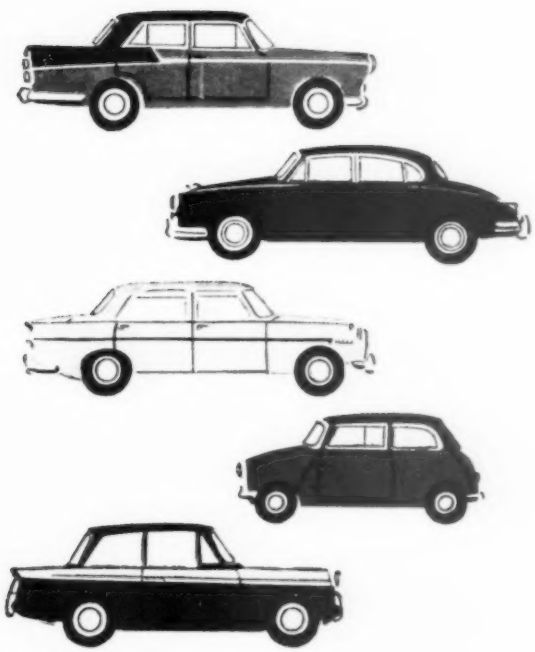
BRICO make the pistons for the Coventry Climax 2½ litre engine—champion Grand Prix engine of 1959.



## POPULARITY

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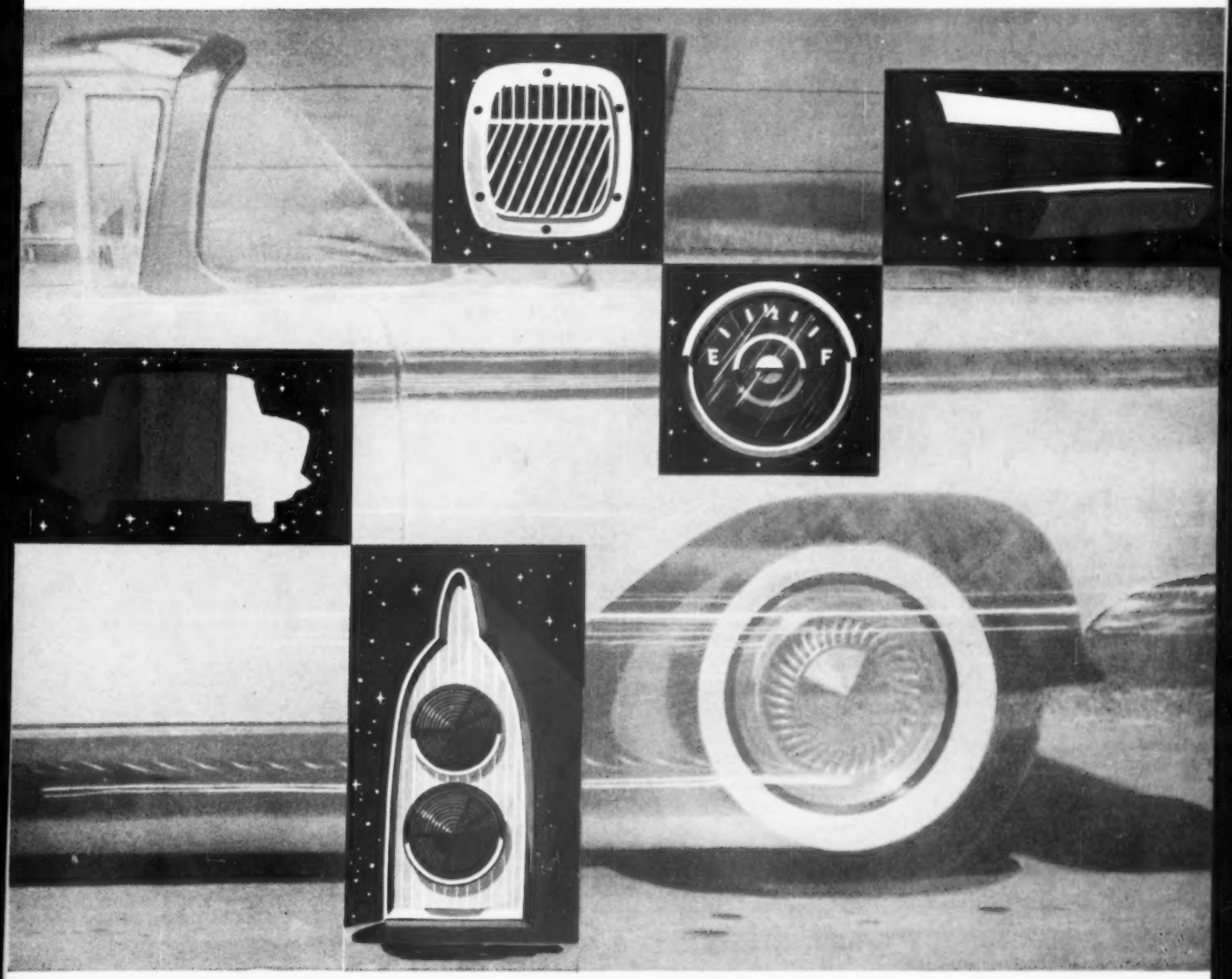


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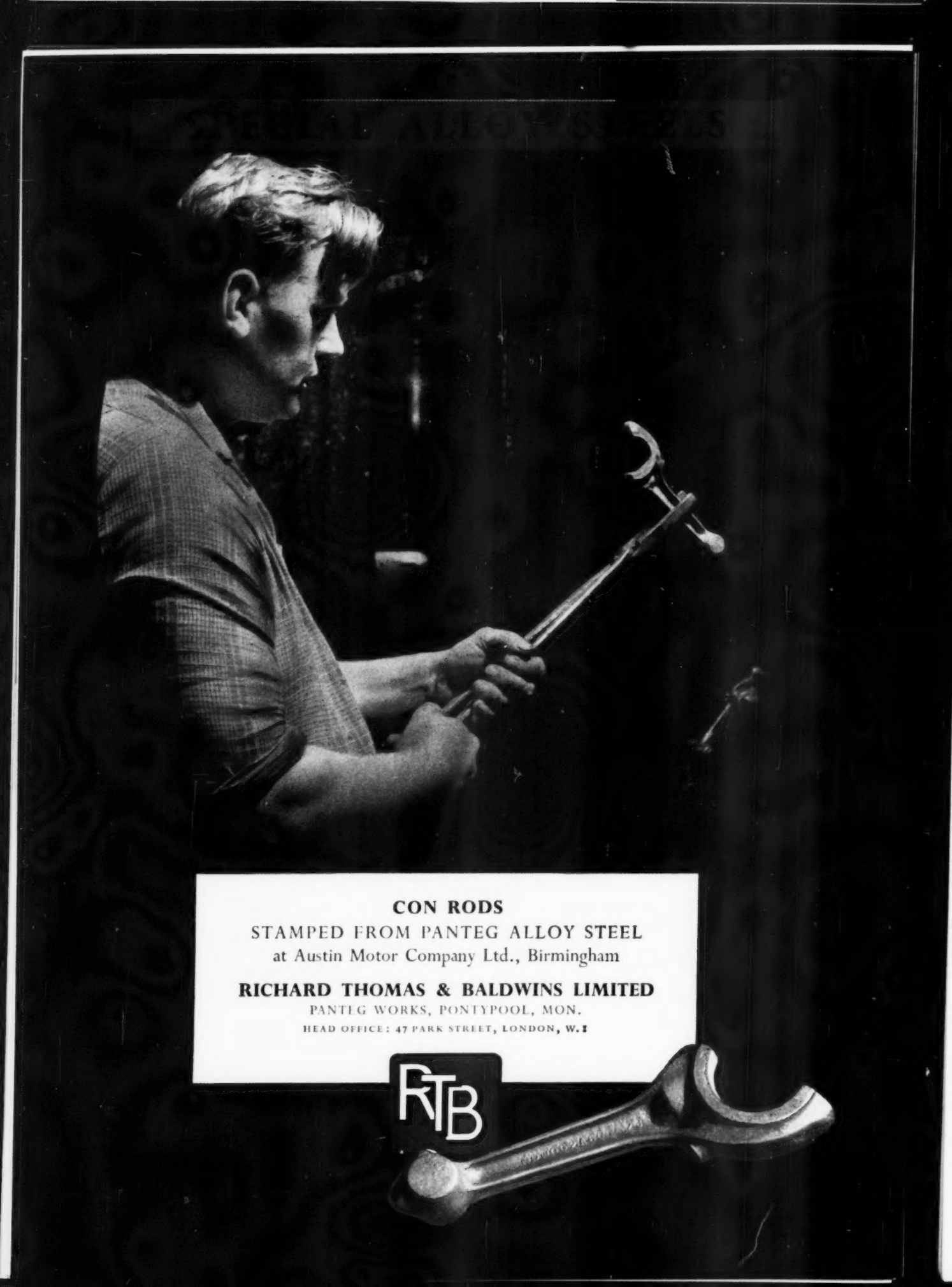
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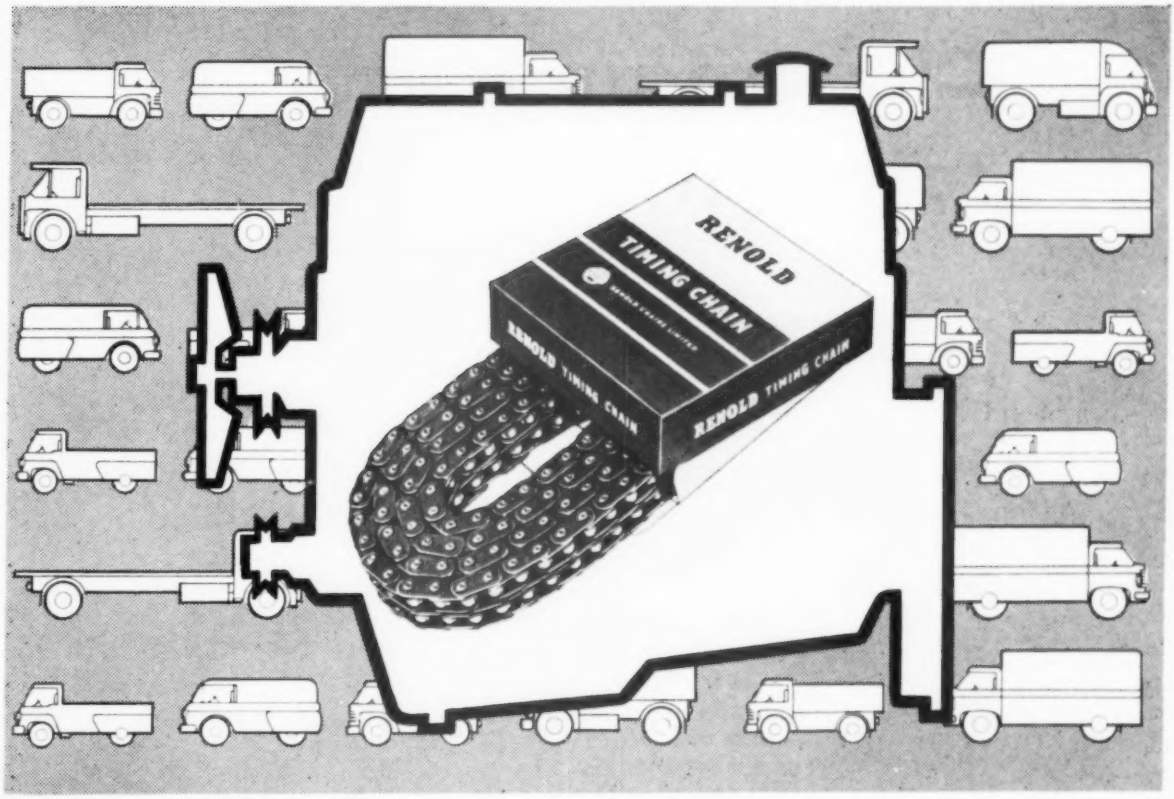


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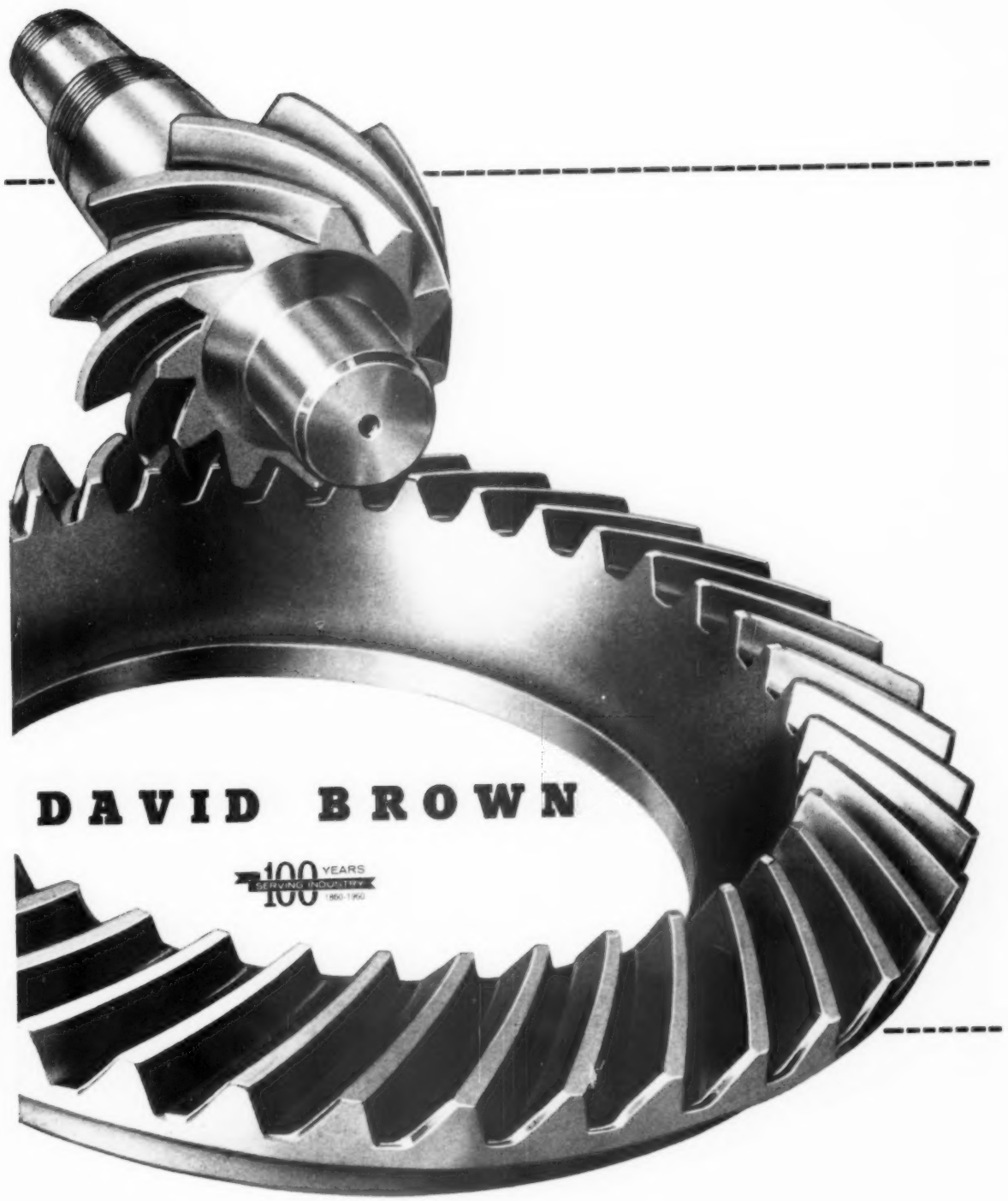


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**Profile ground spur and helical gears:** We are now in a position to supply profile ground spur or helical gears of a very high order of accuracy, particularly in regard to accumulative pitch errors, which are so important on timing gears. Test charts can be supplied if you wish. Our capacity for such gears is up to 11½ inch diameter, 3½ inch face width, 4 to 20 D.P.

**Holroyd**

JOHN HOLROYD & CO. LTD.
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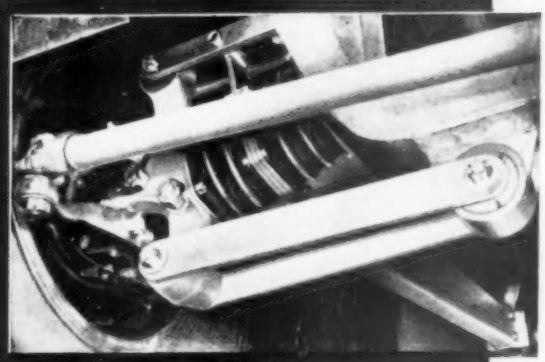
CEC A4

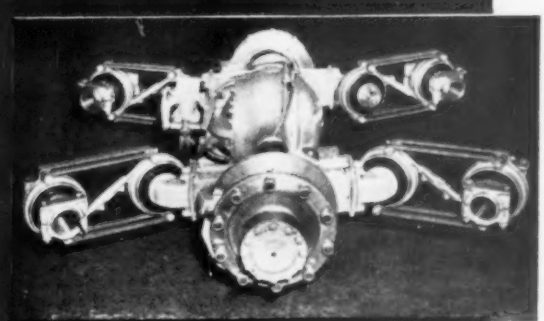
# 55 MILLION MILES ON SINGLE DECKERS

## ....now on Double-deckers: METALASTIK RUBBER SUSPENSION



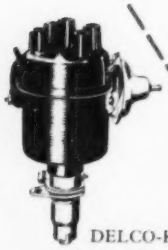
Pioneers in the modernization of many important 'bus features, "Midland Red" have benefited by their 55-million-mile single-decker experience of Metalastik suspension, which they now incorporate in their double-deckers, the new B.M.M.O./D.9. shown above, and also in their C.M.5. Motorway-Express-Coach shown below at M.I.R.A., being tested up to 85 m.p.h.

It is a tribute to the sound principles underlying the Metalastik suspension system (two centre pictures) that the same basic design meets the requirements of these three widely differing services, resulting in economical operation, and a substantial increase in safety.



**METALASTIK**

**METALASTIK LTD., LEICESTER**



DELCO-REMY
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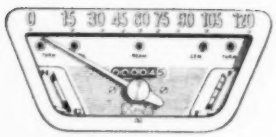
AC Air Cleaners
& Silencers



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a good vehicle starts with

AC-Delco
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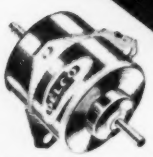
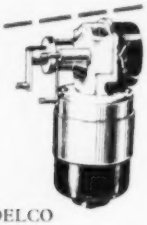
Spark Plugs



DELCO Electric Motors

AC Oil Filters



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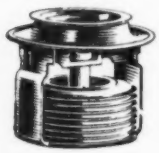
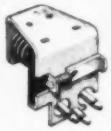
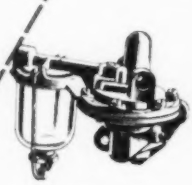


AC Thermostats



DELCO-REMY
Switches



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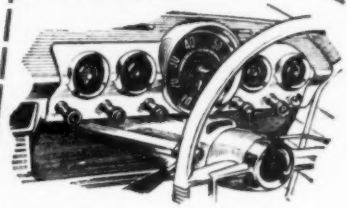

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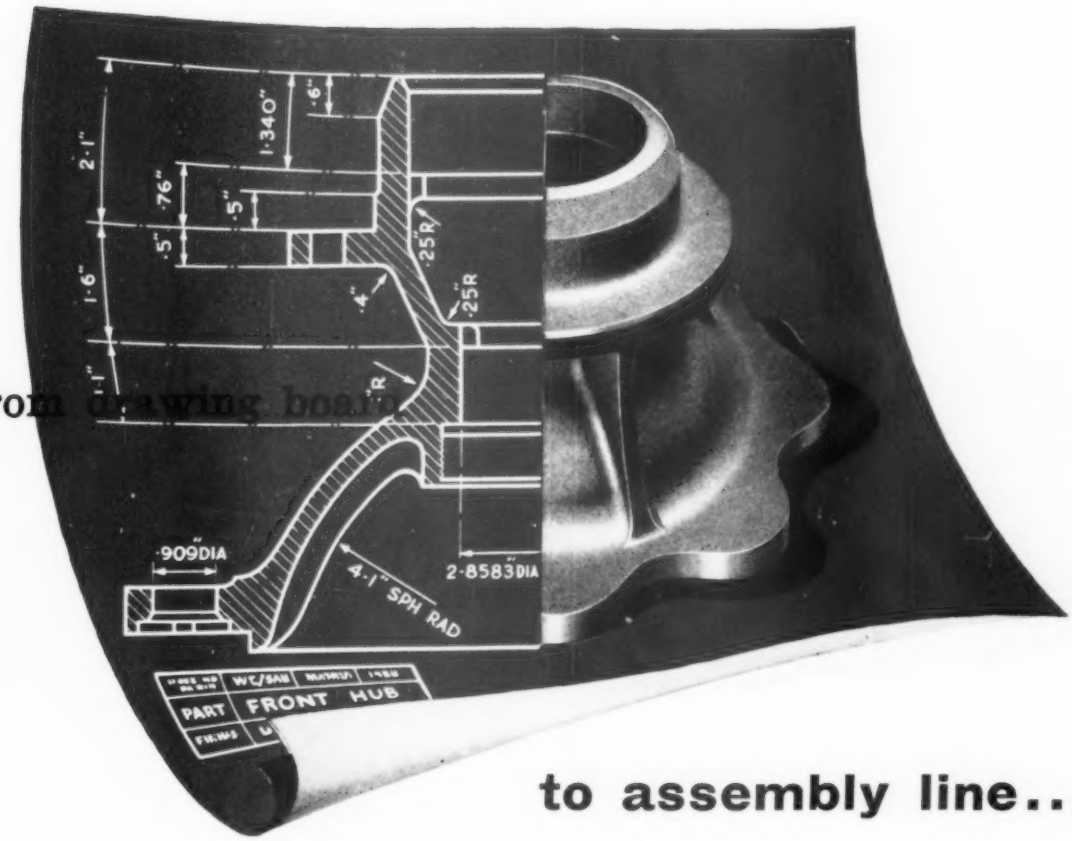


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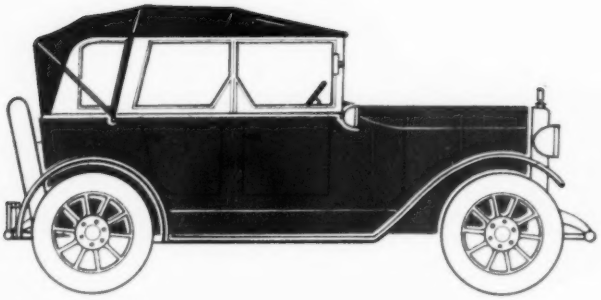

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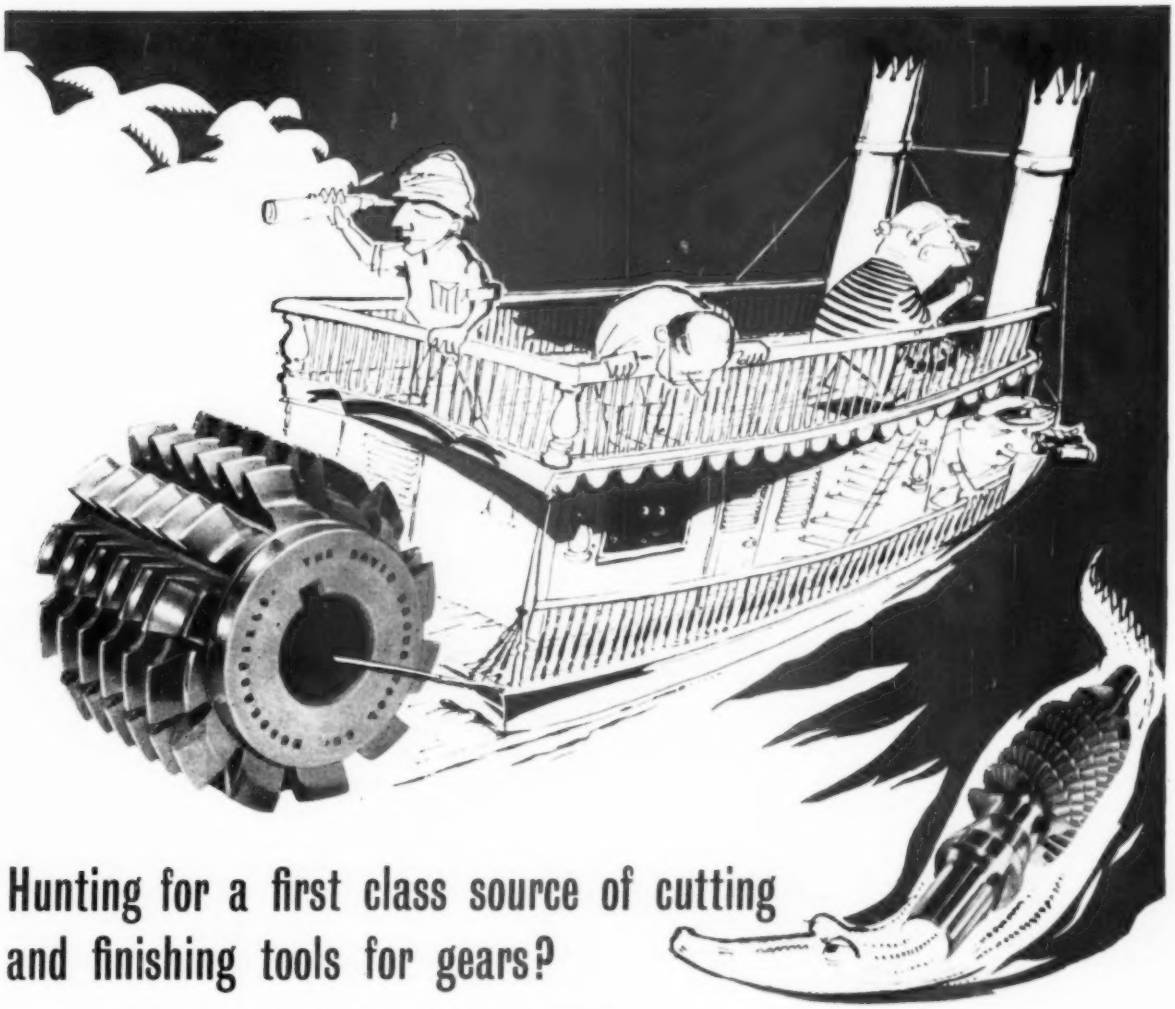

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# NYLON AT ITS BEST IS CALLED . . .

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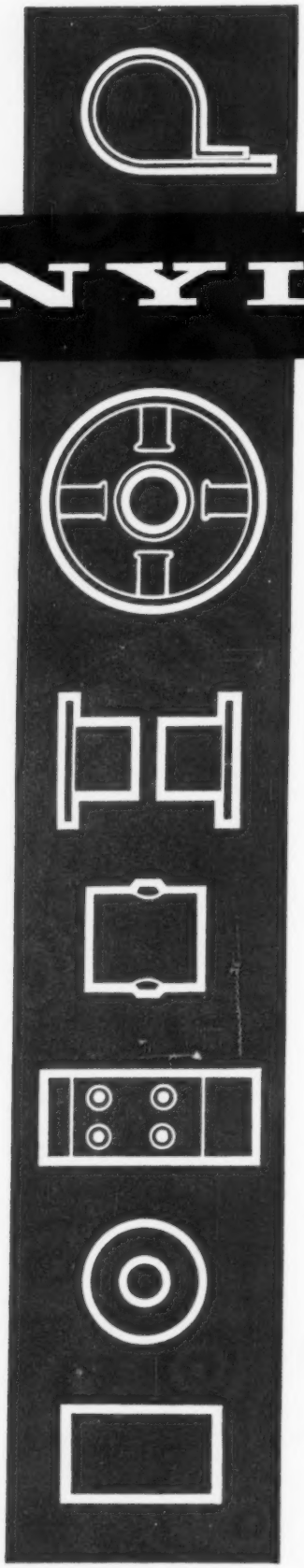

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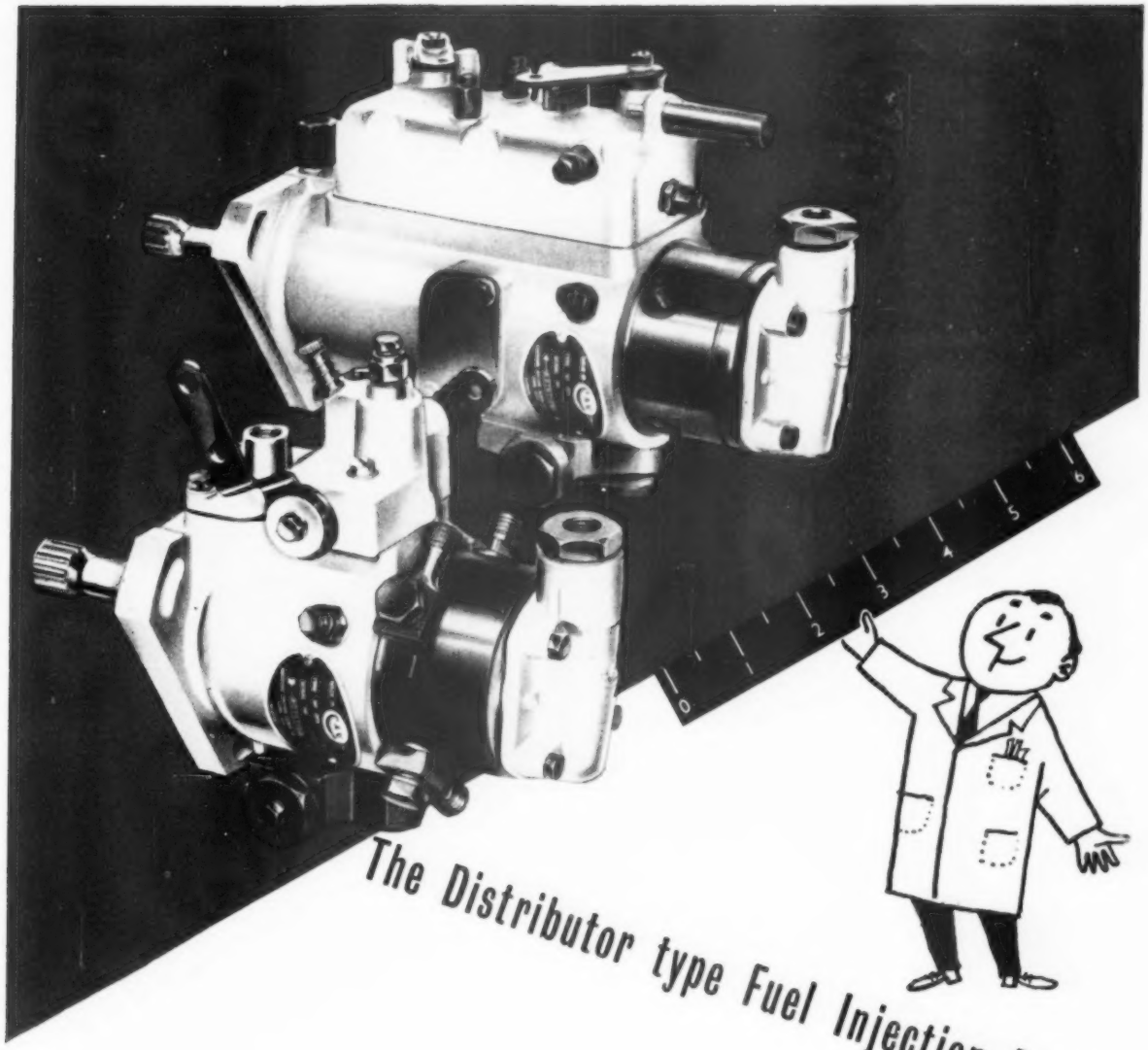


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The DPA distributor type pump is not only very small and light. It is arranged for simple types of drive and can be fitted snugly against the side of the engine, making a very compact installation. Calibration and phasing are not required with this type of pump. The housing is filled with filtered fuel oil under slight pressure, and no special lubrication is required, while dirt and water are excluded. The DPA is ideally suited for high speed diesels.

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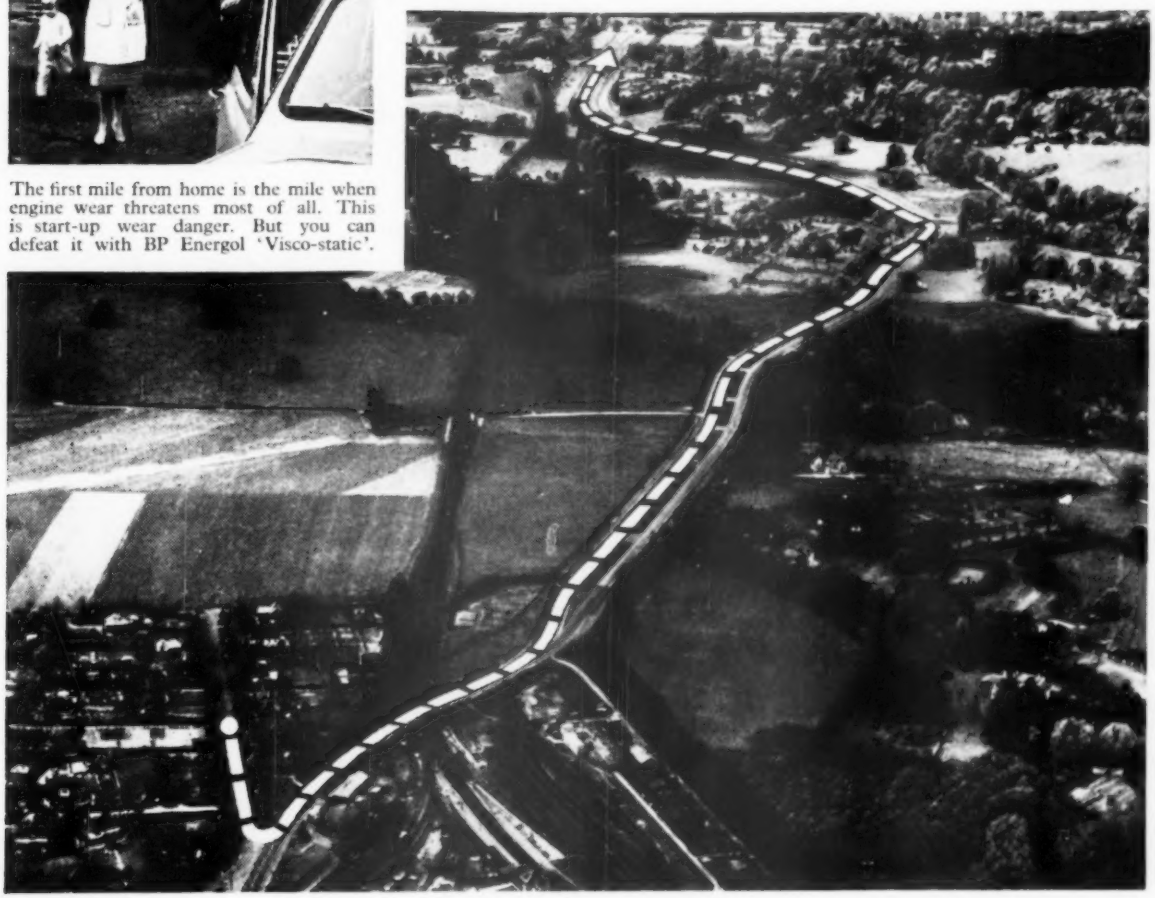
The first mile from home is the mile when engine wear threatens most of all. This is start-up wear danger. But you can defeat it with BP Energol 'Visco-static'.

# The first mile is danger mile for your engine...



## Change to

# BP 'Visco-static'

## the oil that beats start-up wear

**PRESS THE STARTER, back out of the garage, wave to your wife and you're off. It's the first mile of the day. Do you know it's the worst mile of the day for engine wear—the time when wear can be many times heavier than during normal running? This, in fact, is when most cars do most of their wearing out.**

Can anything be done about it? The answer is a decided yes. BP Energol 'Visco-static' motor oil beats heavy start-up wear completely. This has been proved by tests with the radio-active wear detector. As a result you can get many more thousands of miles of good motoring before your car needs overhauling.

**How BP 'Visco-static' beats heavy start-up wear.** First cause of heavy start-up wear is overnight corrosion. Second is failure of ordinary oils to circulate properly when they are cold. BP 'Visco-static' guards vital surfaces against corrosion and as soon as you start up next morning gives immediate oil circulation. This is because BP 'Visco-static' flows freely even in freezing cold. Yet even at racing heat it always has ample body to give proper lubrication.

**Proved on the radio-active wear detector.** Tests on start-up wear in the laboratory and on the road with the radio-active wear detector prove that BP 'Visco-static' removes the start-up wear peak. The result is many more thousand miles of good motoring before your car needs overhauling.

**Save petrol, get easier starting.** With BP 'Visco-static' you gain so many ways. You save up to 12% in petrol because of reduced oil drag. You get easy starting at any time. This amazing oil is also right for all-year-round use, although of course you do need to have regular oil changes.

**Change now.** If your car is in good condition, change now to BP 'Visco-static'. But remember you should make a complete change – drain out the old oil and replace with BP 'Visco-static'.

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A body needs muscles to control movement in very much the same way as a mechanism needs springs. These vital links take the stress and strain of every day rigorous use — nature provides the muscles . . . SALTER provides the springs. Two centuries of experience and development in the manufacture of springs of every type have enabled us to keep ahead of the ever-changing requirements of industry.

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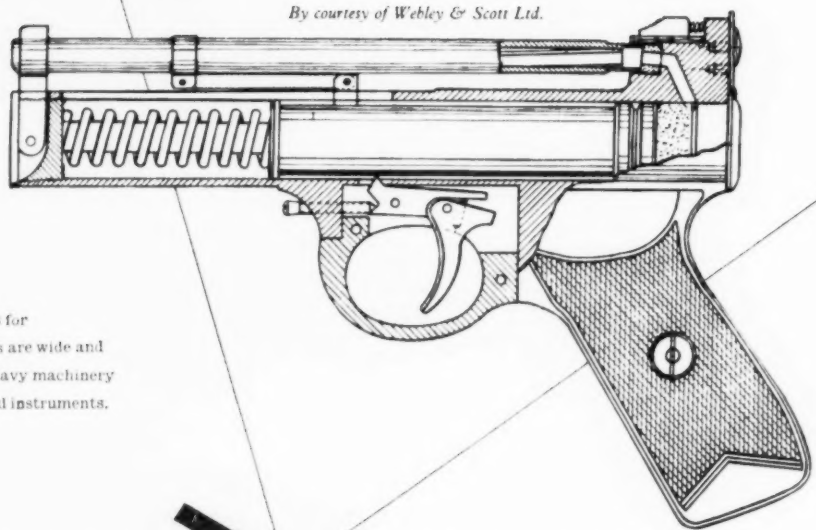
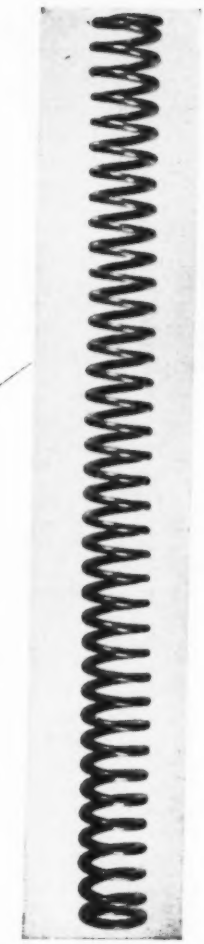


The applications for SALTER springs are wide and varied — from heavy machinery to finely balanced instruments.



For springs with the highest reputation and top performance specify SALTER all-action springs.

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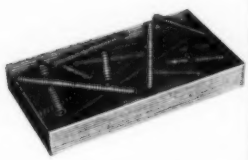
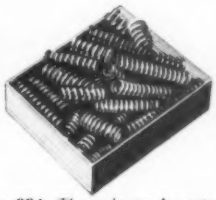
## If not, try another box in the Terry Assorted Springs range



**No. 1200.** Three dozen Assorted Light Expansion Springs, suitable for carburettor control, etc. **13/6.**



**No. 98A.** Three dozen Assorted 1" to 4" long, ⅛" to ¾" diam., 19G to 15G. **5/6.**

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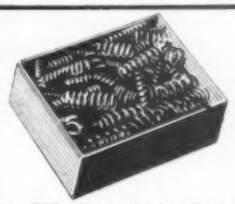
**No. 760.** Three dozen Assorted Light Compression Springs. 1" to 4" long, 22 to 18 S.W.G., ¼" to ½" diam. **6/6.**



**No. 757.** Extra Light Compression. 1 gross Assorted, ¼" to ⅜" diam., ½" to 2½" long, 27 to 19 S.W.G. **15/-.**

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We can only show a *few* boxes. Send us a p.c. for our full list.
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If so, the help of our Design Staff is yours for the asking.

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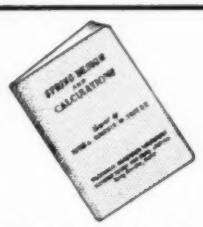

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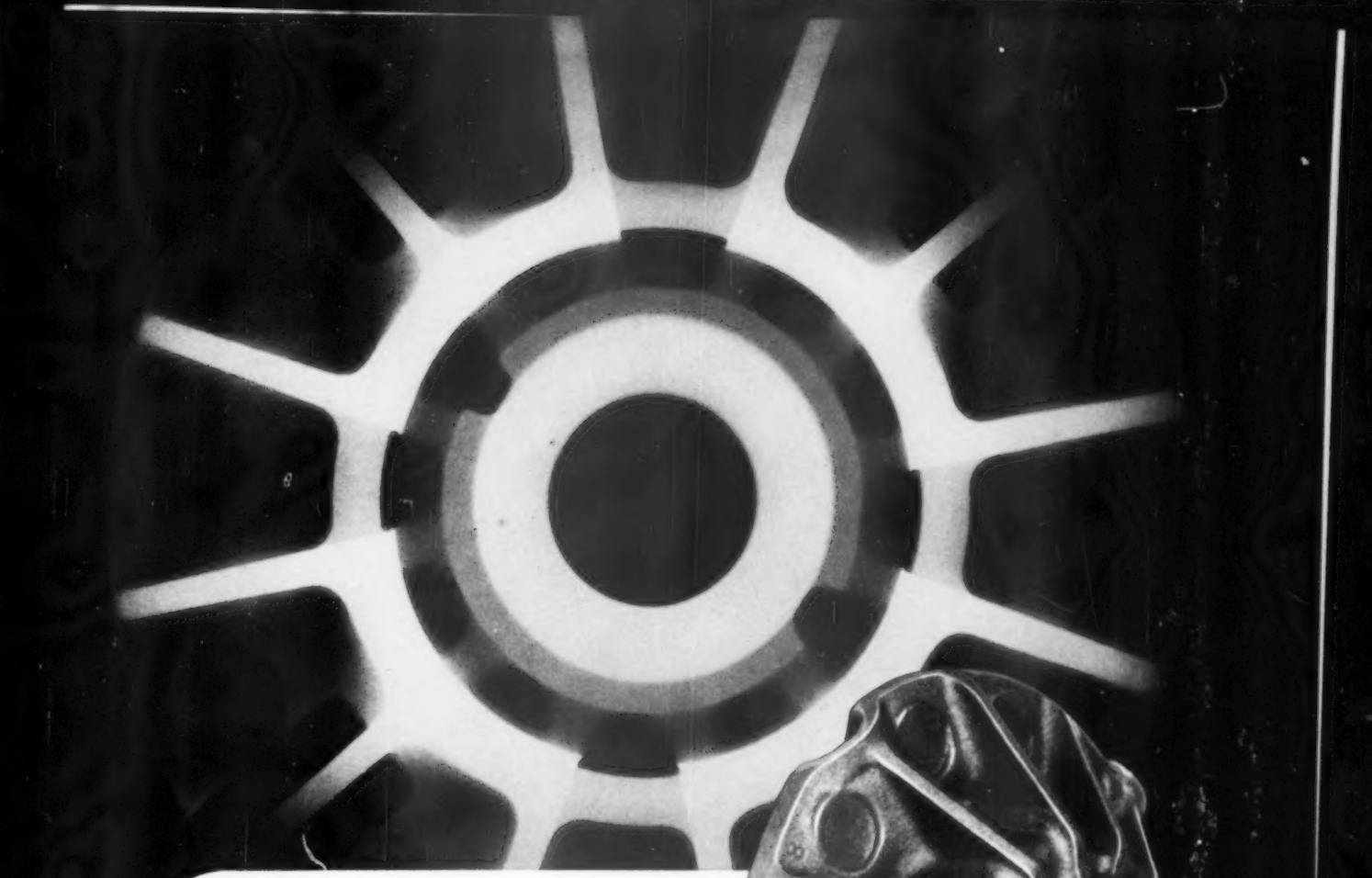

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Our radiographic facilities enable us to conduct checks leading to the best foundry technique for producing consistently sound castings.

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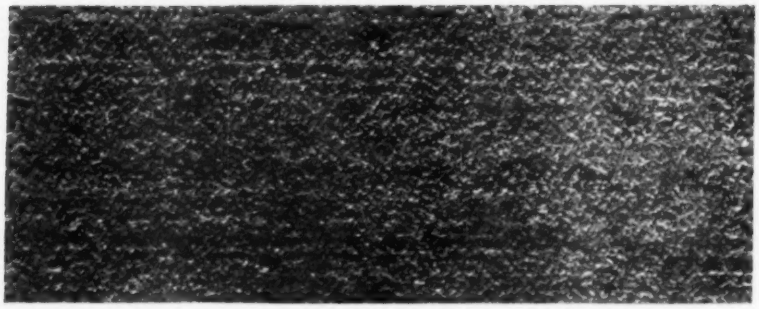
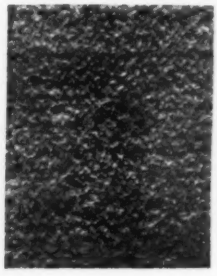
LEY'S





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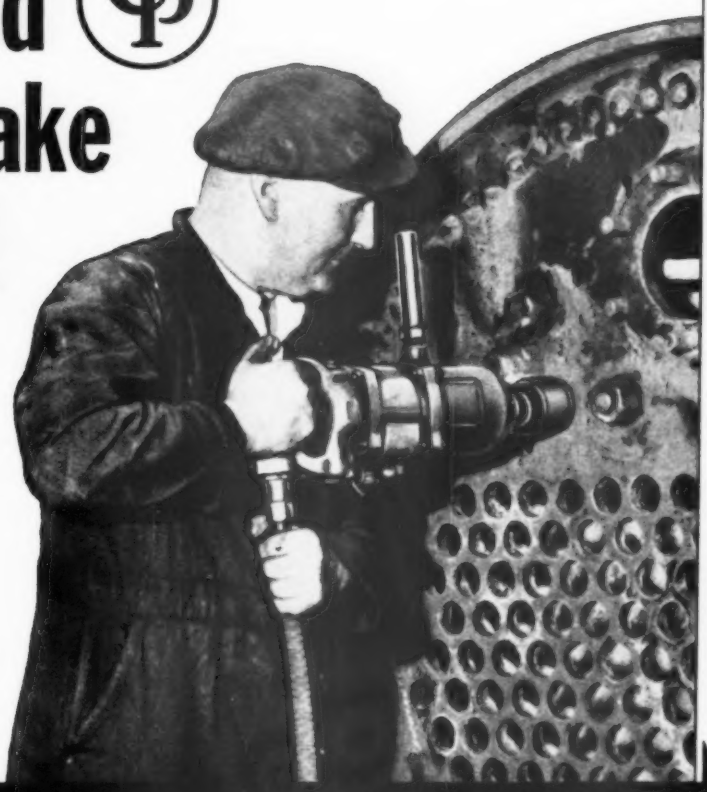

"Power Vane" 317-RS Lever Type Impact Wrench. ¼" capacity

"Power Vane" 337-RAN 90° Angle Impact Wrench. ¼" capacity

"Power Vane" 344-RS Side Handle Impact Wrench. ¼" capacity

"Power Vane" 349-RP Pistol Grip Impact Wrench. ¼" capacity

"Power Vane" 349-RAN 90° Angle Impact Wrench. ¼" capacity

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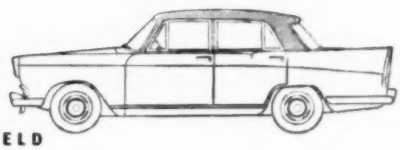

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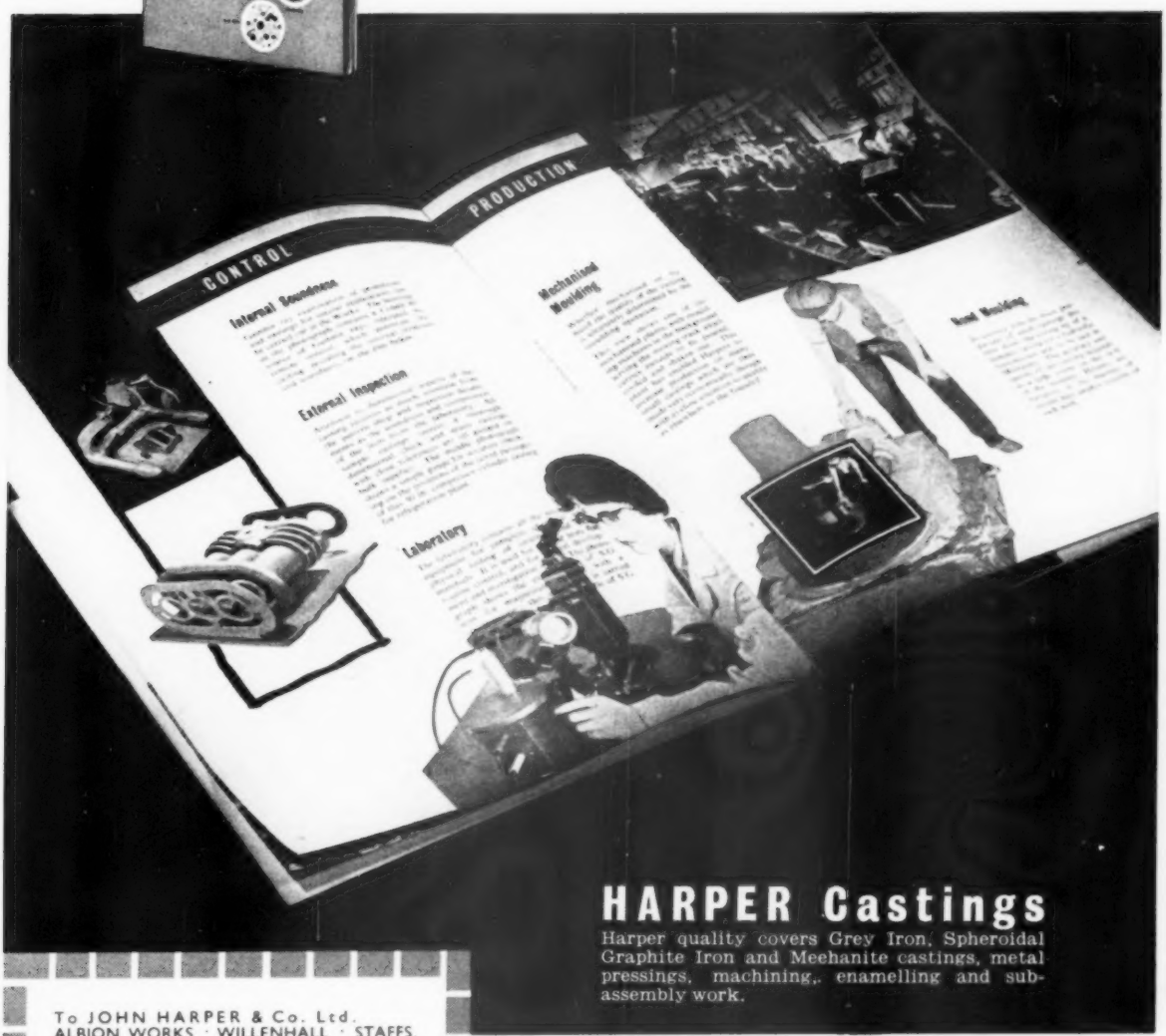


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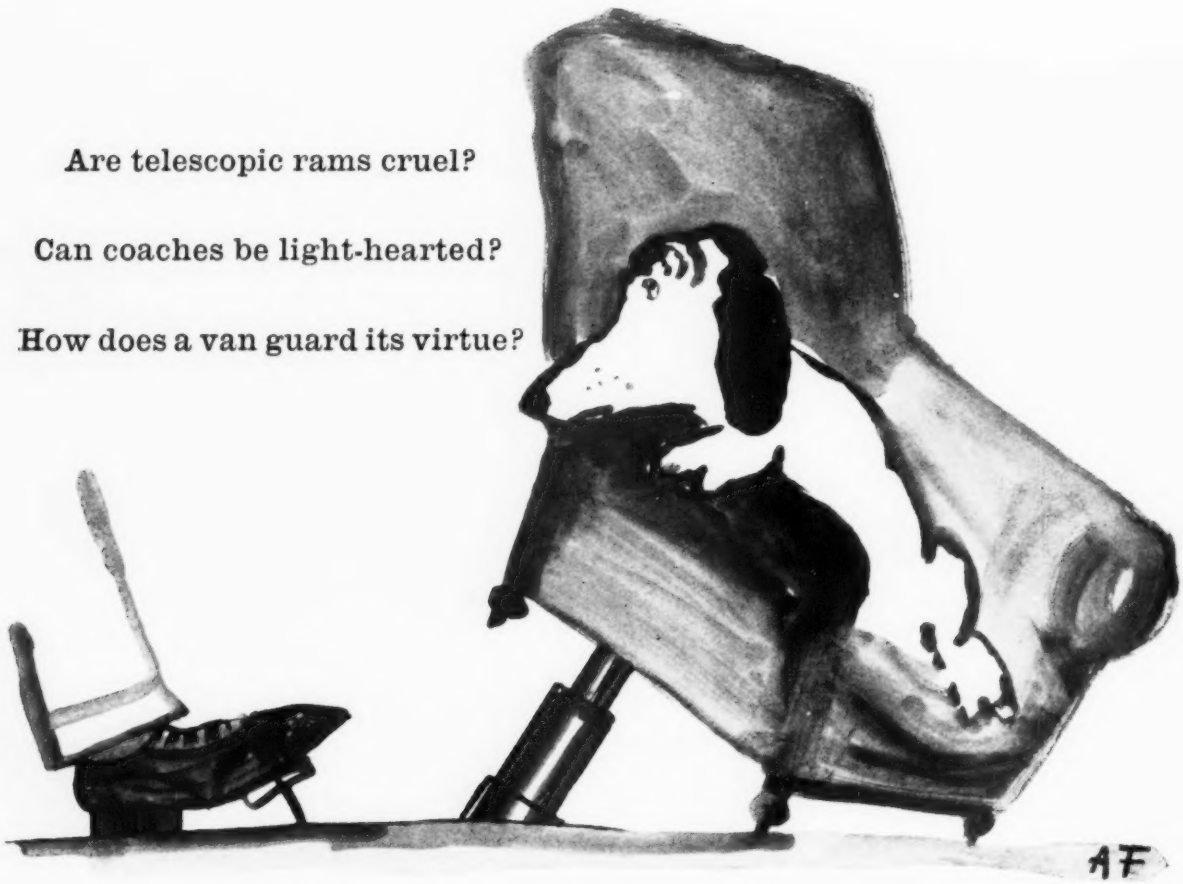


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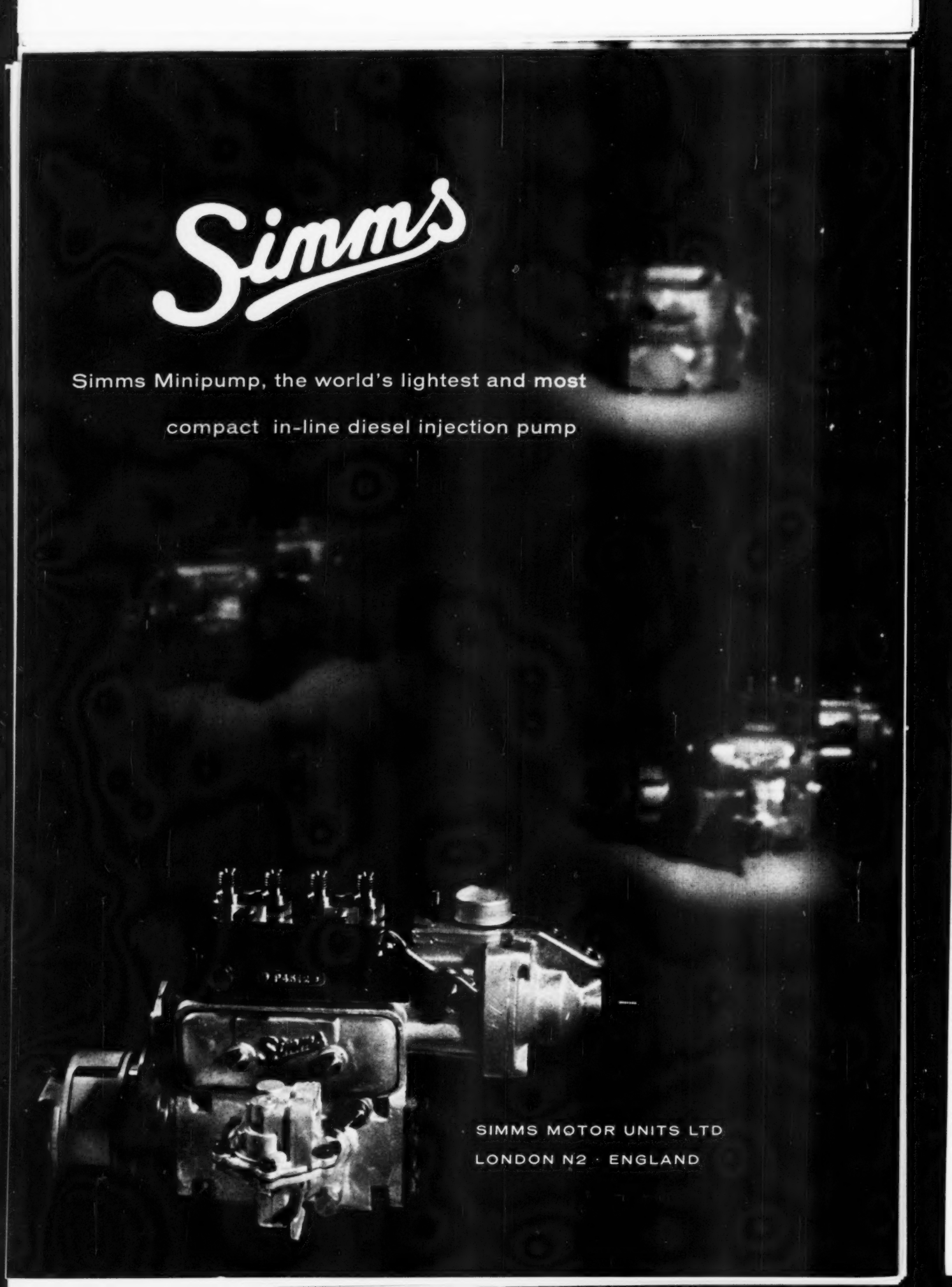
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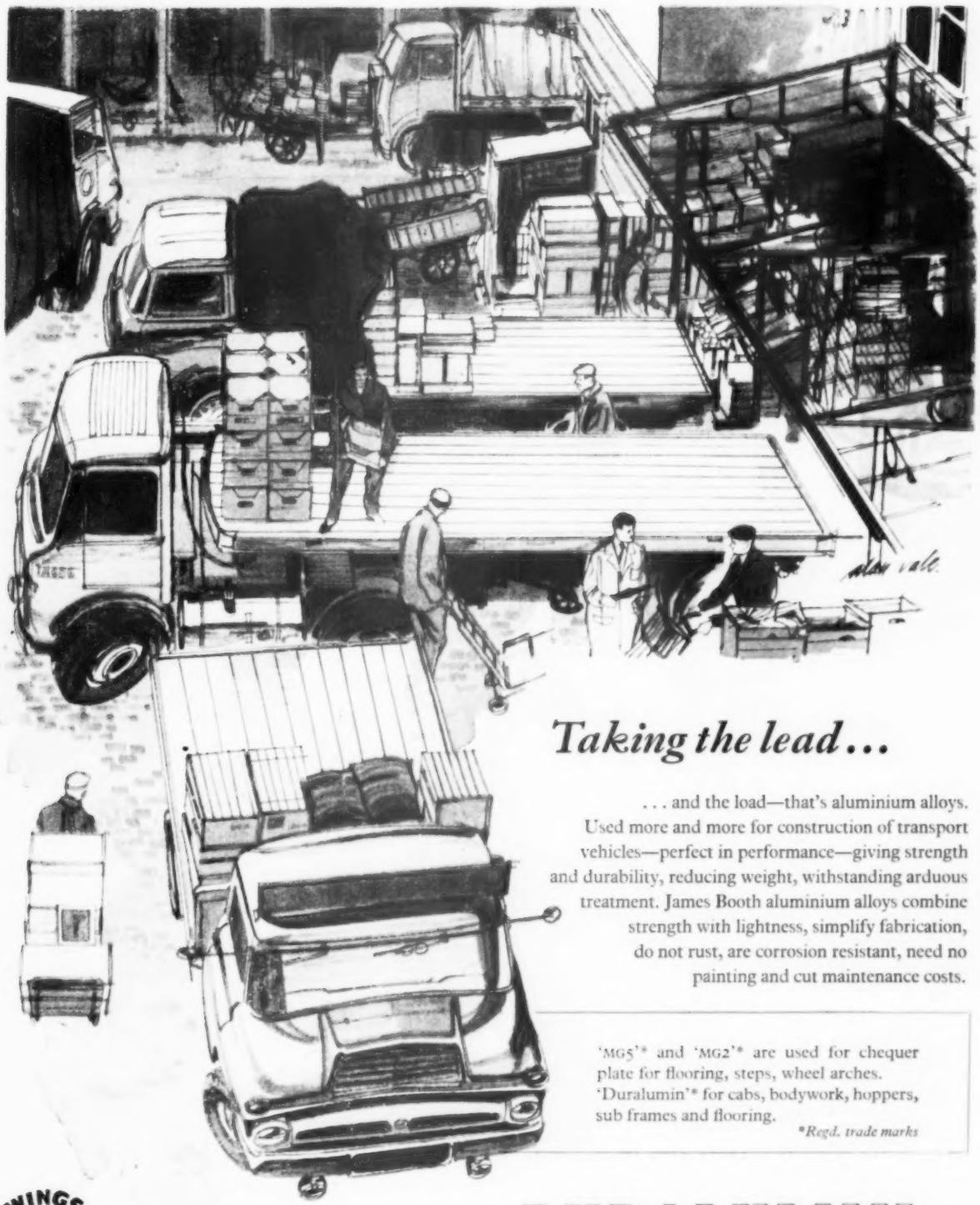

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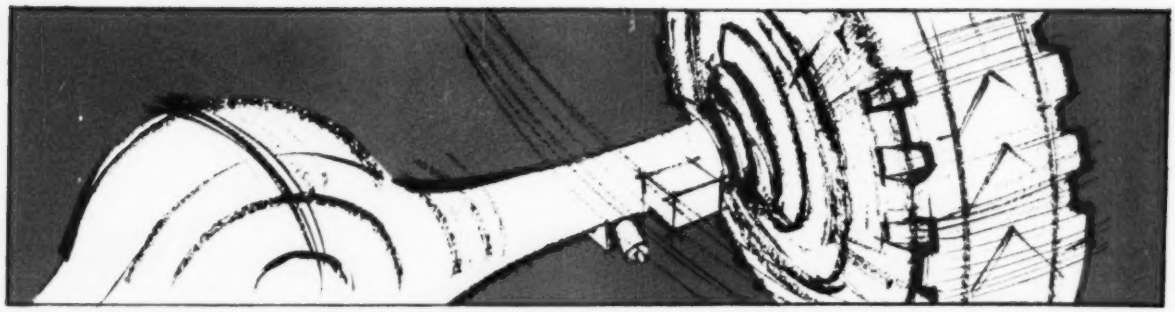

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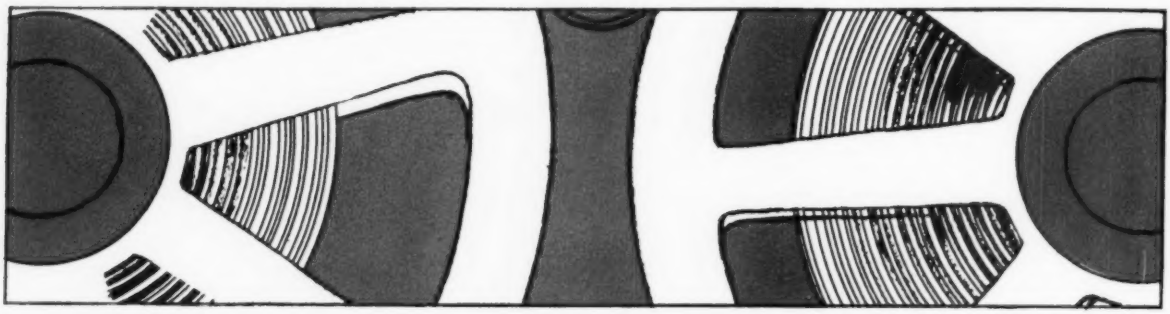

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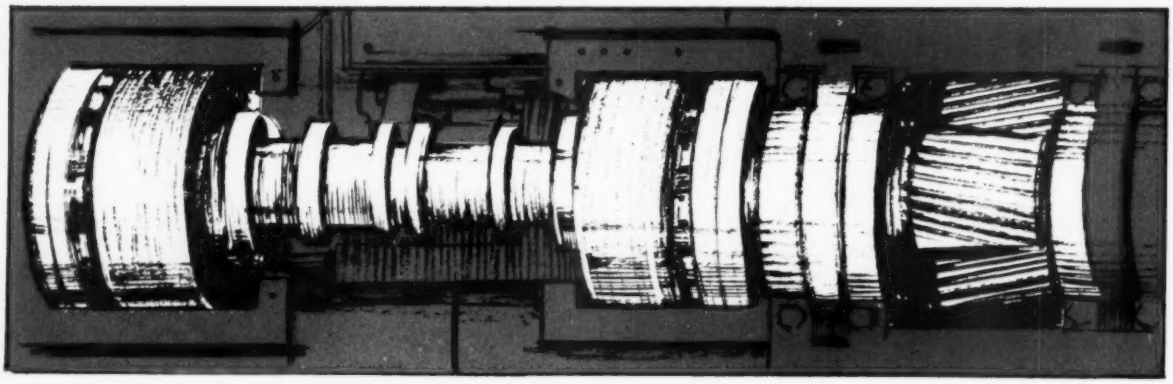

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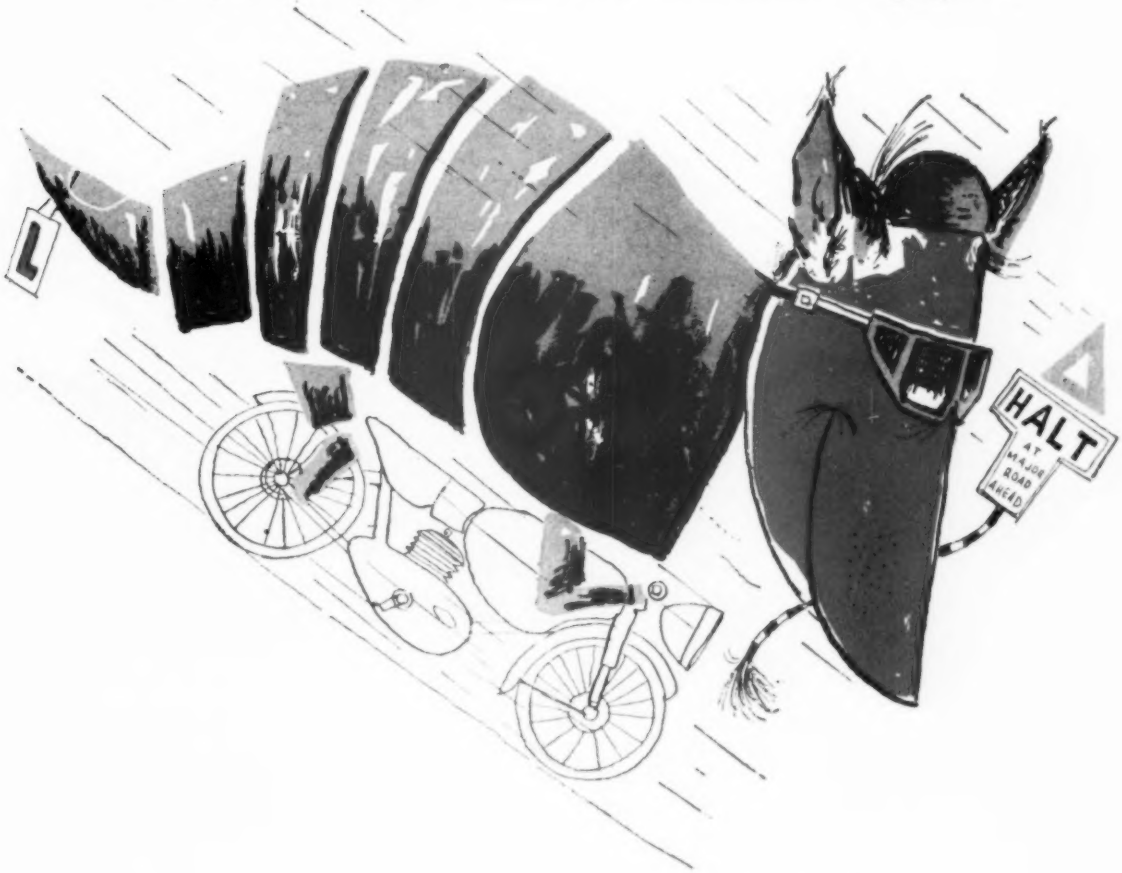


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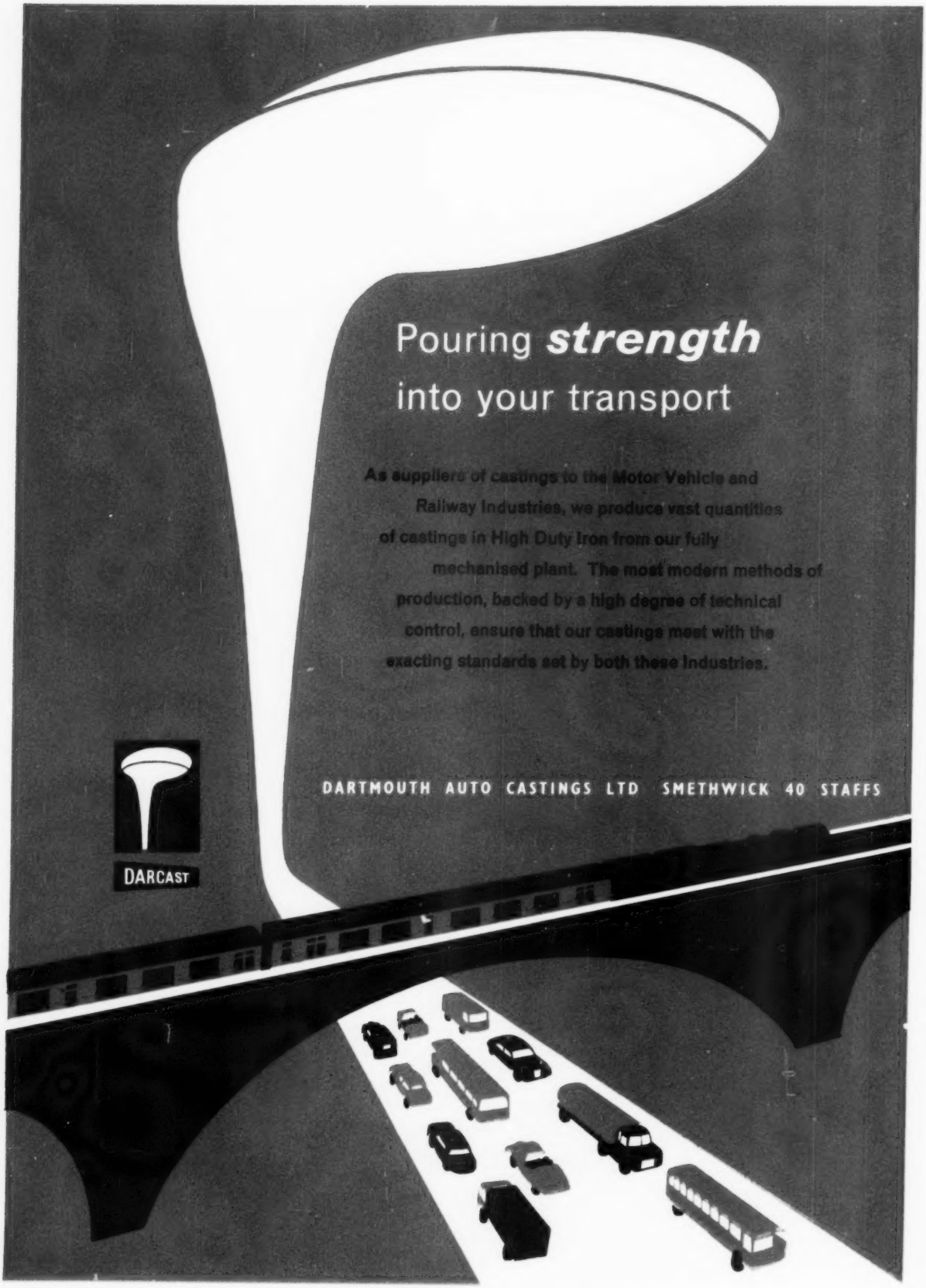
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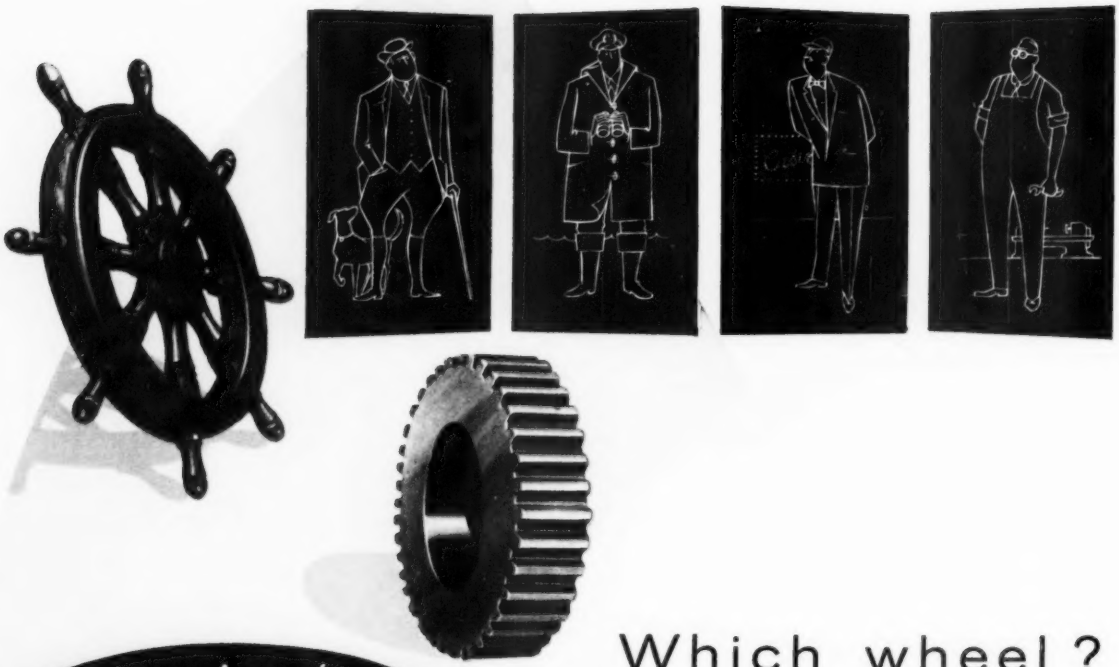

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DESIGN MATERIALS **AUTOMOBILE ENGINEER** PRODUCTION METHODS WORKS EQUIPMENT

# Tappet and Cam Wear

WITH the continuous trend towards increasing power outputs and engine speeds, and the heavier valve spring loadings, wear of cams and tappets is, of course, becoming a major problem. Although the ultimate answer may be the adoption of the overhead camshaft layout, serious attempts are obviously first being made to overcome the troubles with the more common layouts. The problem is complex, since the wear can take any one of three forms, that is, scuffing, pitting or heavy polishing, and measures taken to obviate one may aggravate another. Scuffing is most likely to occur at high speeds and during running-in, whereas pitting is more frequently initiated at slow speeds. Heavy polishing can arise as a result of excessive activity of E.P. additives used to prevent scuffing.

Only if mechanical design improvements to obviate vibration and reduce the loads in general are impracticable should other solutions be sought. Among the alternatives are the employment of more suitable materials for the cams and tappets, and, as a last resort, the use of oils charged with chemically active additives that prevent welding due to high local temperatures.

There is, perhaps, a natural temptation to seek a remedy first in respect of lubrication, but for several reasons this can be a mistake. Scuffing can be prevented in some instances by the use of oils with chemically active additives, such as thiophosphates. These additives, however, by attacking along the grain boundaries, can encourage pitting, especially with chilled irons; they also can cause rapid wear by chemical polishing, an action most likely to occur with steel.

A compromise might be effected by using additives that are not so active, but the use of these special lubricants could be illogical, not only because they are costly but also because an additive oil that is suitable for one set of cam and tappet materials can be completely unsuitable for another and can quickly cause serious damage. Either valve actuating gear should be designed to operate satisfactorily with unfortified oils or, failing this, perhaps some standardization in respect of materials and designs could be agreed upon by engine manufacturers, in consultation with the oil industry, so that a generally acceptable, openly defined E.P. level could be specified. In the United States, all the manufacturers have virtually agreed to use hardenable iron as their cam and tappet material.

Pitting is most likely to occur on vehicles operated at slow speeds. Although, as has already been mentioned, it can be aggravated by chemical attack along the grain boundaries, it is basically due to over-stressing. If the base circle of the cam is too small, it may be impossible to obtain the required negative decelerations of the tappet, except by the employment of an unduly small nose radius. This latter measure gives rise to high thermal and mechanical stresses on the nose, and aggravates pitting and scuffing problems. If, on the other hand, the base circle is too large, sliding speeds are high and this tends to cause scuffing and polishing on other parts of the cam. Theoretical considerations suggest that optimum conditions, so far as the avoidance of scuffing is concerned, could be obtained in many instances by modifying cam profiles to give higher positive and lower negative accelerations, with a more abrupt transition. This is liable to increase the amplitudes of vibrations in the valve train, unless other measures are also taken, and so a compromise may be necessary.

Maximum pressure, on the nose of the cam, should be restricted to about 150,000 lb/in$^2$. Edge loading, which may cause very high local stresses, must be avoided. This is generally done by the employment of spherical-ended tappets; however, it is also essential for the geometry of the layout and alignment of the components to be rigorously controlled, and obviously the stiffness of the camshaft and its housing must be adequate. Tappet rotation is desirable and, in many instances, the weights of reciprocating components could, and ought, to be reduced.

The metallurgical structure of the material used is of course a decisive factor, but the thermal properties, too, are of significance because of the importance of avoiding high local temperatures. If scuffing occurs on the flank of the cam, the thermal capacity and conductivity of the tappet should be improved, whereas if it is found on the nose, those of the cam are most important. This is because, in that part of the cycle during which the flank is taking the load, the area of contact on the tappet is virtually stationary whereas on the cam it is moving, and in the other part, that is, when the nose is under load, the circumstances are the opposite.

There is considerable scope for joint consultation between manufacturers and the oil industry on the subject of tappet wear. For example, at present there are at least fourteen different test specifications for the acceptance of lubricants as suitable in respect of cam and tappet wear, and obviously this number could be drastically reduced. It is also desirable for agreement to be reached on the number of tests of each kind to be carried out: isolated failures have been known to occur, and misleading results obtained. The problems involved beset almost every designer and so, during discussions on this subject, any temptation to withhold information should be overcome.

# Triumph Herald

*Part 1: The Backbone Type Chassis Frame, the Construction of the Bodies, and the 948 cm³ Engine*

*The styling of the Herald is distinctively angular. A good feature of the saloon version is the unusually large glazed area*

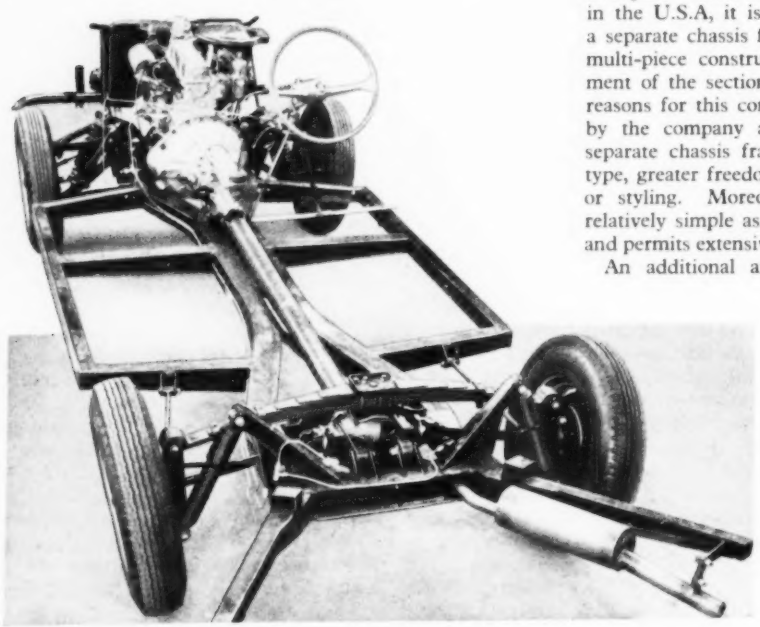
THERE is little doubt that the Triumph Herald car is one of the most interesting designs introduced since the War. Although it follows convention in having the engine at the front and the driven wheels at the rear, its layout departs from current British orthodoxy in several important respects. Each of these departures has been adopted, after careful consideration, because of the real advantages it offers with regard to either performance—in its widest sense—ease of manufacture, or operating costs in respect of not only the price of petrol and oil, but also servicing, repairs and insurance. The manufacturers rightly felt that the minimization of such costs deserved closer study than it has in many instances been given.

A very high standard of handling has been attained in the Herald, as will be confirmed by any experienced driver who has tried the car. The weight distribution is good, while the adoption of independent rear suspension, of modified swing axle type, results in a high degree of comfort and wheel adhesion. Accuracy of control is assured by the use of rack and pinion steering gear.

The driver's field of vision is good, with little obstruction. In fact, the Herald is particularly praiseworthy in this respect, since it has a low bonnet and boot, with the four corners of the vehicle clearly in view; the glazed area is unusually large in relation to the body size, and on only one of the body types are there any significant blind spots. An admirable safety feature is the use of a telescopic steering column, designed to collapse in the event of heavy frontal impact, and thus to reduce the risk of chest injury to the driver in the event of an accident. This arrangement has the added advantage of permitting adjustment of the column length, to suit drivers of different statures.

At a time when unitary construction has become general for small and medium-size cars in Britain and other European countries, and when its popularity is increasing in the U.S.A, it is significant that the Herald should have a separate chassis frame. Not only this, but the body is of multi-piece construction with bolted joints for the attachment of the sections to the frame and to each other. The reasons for this complete change of method of construction by the company are certainly logical. By the use of a separate chassis frame, which is virtually of the backbone type, greater freedom is given for alterations of body design or styling. Moreover, the employment of a number of relatively simple assemblies and pressings facilitates tooling, and permits extensive sub-contracting.

An additional and major advantage is that accidental



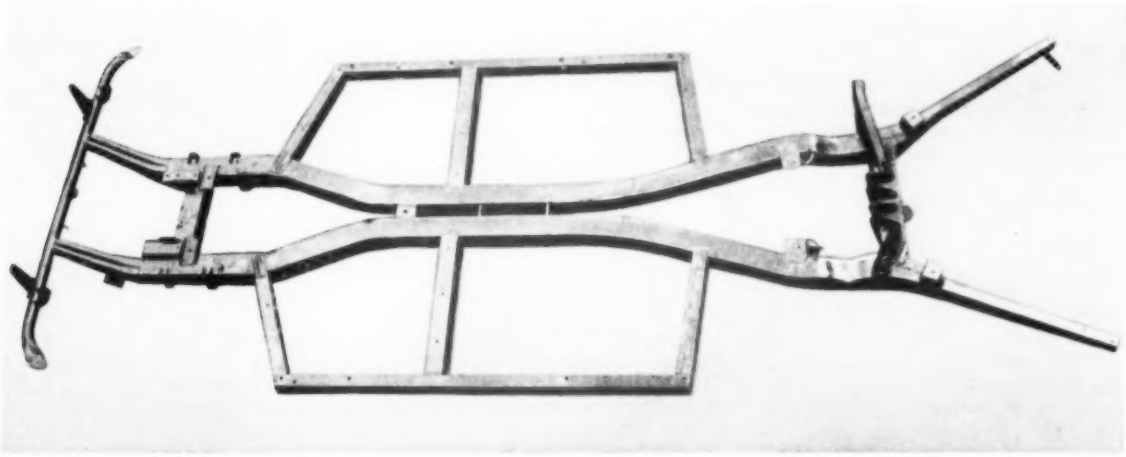
*This view shows the general layout of the Herald chassis. The transmission line is above the frame, and the leaf spring of the swing axle rear suspension is carried on the cast iron casing of the final drive unit*

damage tends to be localized, and repair is therefore easier than with a unitary structure. Certain insurance companies have, in fact, been sufficiently impressed to specify a lower premium for the Herald than for other cars of similar size. In view of the high cost of insurance today, this is a real benefit to the owner.

Important as are the advantages claimed for the Herald's construction, it will be appreciated that there are several potential disadvantages in comparison with a unitary design. In the first place, careful design is necessary if the strength : weight ratio of the combined frame and body is not to be inferior to that of the equivalent unitary structure. Moreover, flexing between the frame and the body is almost inevitable, and can give rise to shake and rattle; it is less easy, too, to seal bolted than welded joints against the entry of dust and water.

It need hardly be stated that, from the start, the manufacturers were well aware of these problems. The questions of strength : weight ratio and rigidity have been tackled directly by making both the frame and the body structurally efficient, and certainly the saloon unladen weight of 1,764 lb is very little greater than the average for 1-litre cars of unitary type. Rattles and leaks were admittedly troublesome, but painstaking development work has resulted in what is probably a generally acceptable standard in these respects.

A matter of criticism in respect of many present-day cars is the large number of joints, mainly in the suspension and steering systems, that require regular and relatively frequent lubrication. In the Herald, however, extensive use is made of unlubricated and sealed bearings throughout the chassis, even on the universal joints of the transmission. As a result, routine servicing is confined to the quick and simple tasks of topping up the engine sump, battery and tyres; changing the engine oil should be done at 3,000 mile intervals. Attention to certain of the chassis bearings is only required every 12,000 miles, and the other bearings can operate satisfactorily for the full period between major overhauls.



*The frame is of the backbone type, and the main longitudinals are of box section. Welded to the front extensions is a tube forming a bumper*

**Chassis frame**

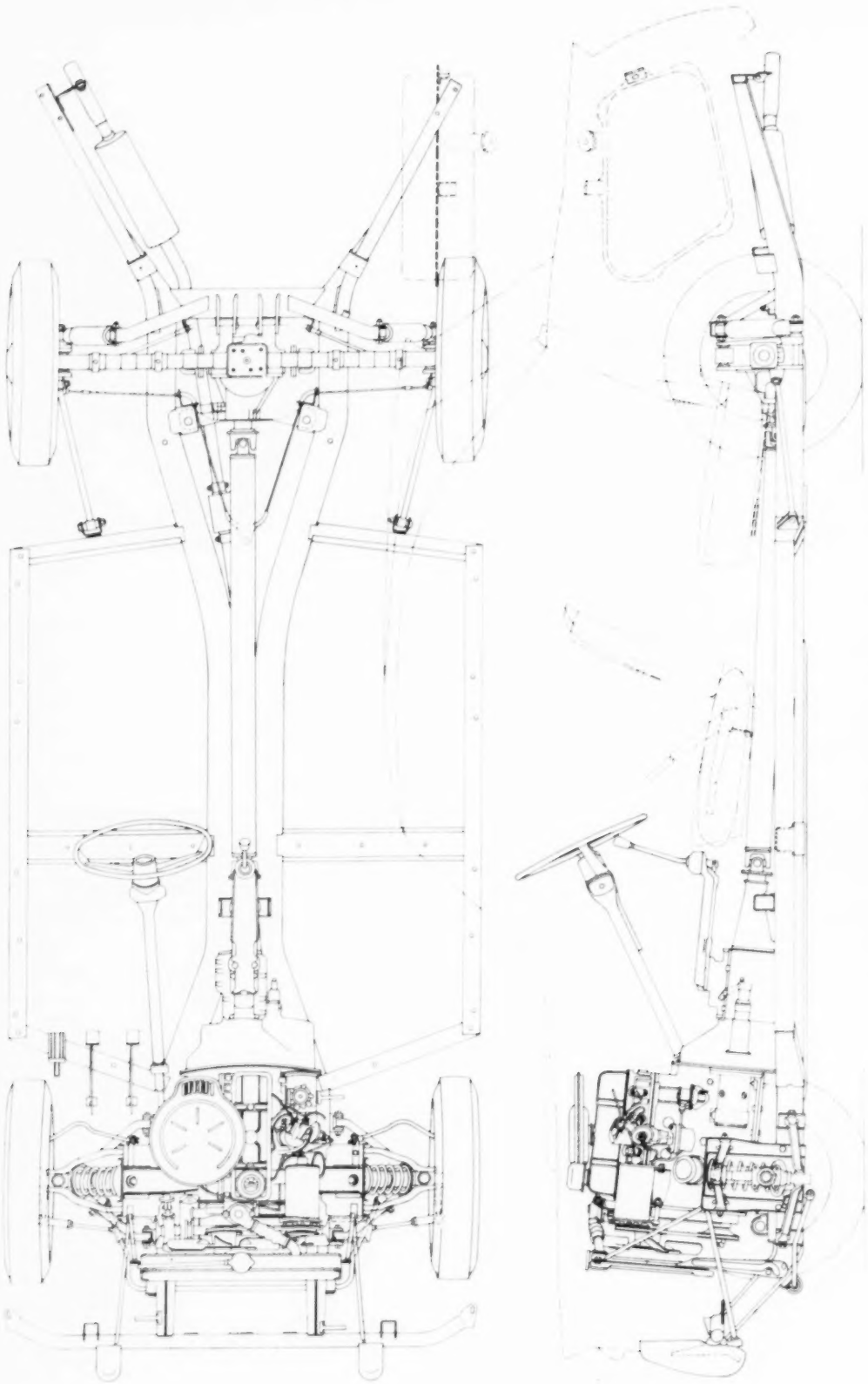
Although the adoption of a separate chassis frame may be regarded by some as a reversion to an earlier convention, there is nothing antiquated about the frame layout chosen. The design has clearly been worked out from first principles, with the object of achieving the best possible utilization of every pound of steel. Although this all-welded structure has a bare weight of only 125 lb, its torsional stiffness is 30 per cent of that of the complete car. It will, of course, be appreciated that, when the frame is assembled to the body, its actual contribution to the combined torsional stiffness is greater than that figure. A noteworthy feature of the frame design, particularly valuable where the car is used on really bad roads, is that the complete transmission line, from gearbox to half-shafts, is protected from damage.

In its essence, the frame can be regarded as being of the backbone type; in plan view it is virtually the shape of two letters Y placed leg to leg. Its basis is two box-section longitudinals, which are continuous from the mounting for the front suspension to that of the final-drive unit. The box section is formed by welding a shallow channel inside a deep one; both the channels face inward, and the pressings are of 17 s.w.g. material. Apart from small indentations in the top face of each member, to give working clearance where necessary, the overall dimensions of the section are constant, at 3·00 × 3·25 in; the inner channel has a flange width of 0·69 in.

For about the first 16 in from their leading ends, the members are parallel, and their outer faces are 19½ in apart. Over the next 18½ in they converge until they are 8½ in apart, and this spacing is maintained for a further 26 in. A relatively gradual divergence follows: in about 32 in, the members separate to 22½ in apart, and this is held for the final 14 in of their length.

There are extensions of the longitudinals to front and rear. The forward extensions are parallel, as viewed in plan, but have a considerable upward inclination. They are of tapering, rectangular section, and each is fabricated from two 17 s.w.g. top-hat section pressings welded together along their flanges; the plane through the joints is vertical. The extensions at the rear are splayed and slightly inclined upwards; they also are 17 s.w.g. pressings. Their section is tapered and mainly of channel form, though they are boxed in by a plate at the extremities and by gusset pressings where they are attached to the main members. The leading extensions carry a transverse tube, of 1½ in diameter and 16 s.w.g. wall thickness, which forms the concealed front bumper and carries brackets for the over-riders. Whereas the rearward extensions are primarily supports for the rear of the body, that on the right also carries the rear end of the exhaust system.

Apart from the bumper tube, there are five cross members of various kinds between the longitudinals. The front cross member is of boxed, two-channel construction similar to



REPRODUCTION OF THE GENERAL ARRANGEMENT DRAWING OF THE TRIUMPH HERALD CHASSIS

*The roof lines and seating positions of the three body types—saloon, coupé and convertible—are indicated. Wheelbase and track dimensions are respectively 7 ft 7⅓ in and 4 ft*

that of the longitudinals; its ends fit between their flanges, to which it is welded. Both channels of this cross member are 16 s.w.g. pressings. The main one measures 2·72 × 2·88 in, and the flanges of the closing channel have a width of 0·75 in. Each joint between the cross member and the longitudinals is reinforced at the top by a gusset plate and at the bottom by a butt-strap.

Those portions of the longitudinals that lie close together are bridged at three points. Immediately to the rear of the convergence is a horizontal, 12 s.w.g. lipped pressing that carries the rubber mounting unit for the rear end of the gearbox. It fits between the inner channels of the members and is welded to the top flanges. Behind it are two vertically disposed, transverse gussets. They are of approximately rectangular shape and have a peripheral flange. The flanges face rearwards, and the attachment of the gussets to the inner channels of the longitudinals is by a fillet weld at each side, at the front.

The rear cross member is of a construction and gauge similar to that at the front but has a 3·00 × 3·25 in section. Apart from being longer, it differs from the front cross member in being pierced near its right-hand end to provide passage for the exhaust pipe. A reinforcing sleeve fits into the holes in the webs of the channels and is welded in position. Symmetrically disposed on each side of the middle of this cross member are two pairs of vertical brackets, which carry the support bolts of the rear mounting of the final-drive unit. The brackets are of arrow-head shape, with stiffening flanges, and are fillet welded to the upper and leading faces of the member.

Various brackets are welded to the longitudinal members. Above and slightly ahead of the front cross member are two lipped horizontal brackets that carry the engine front mountings and the steering rack. Bolted to the outer face of each longitudinal is the fabricated turret bracket carrying the upper wishbone, coil spring and damper of the front suspension. These suspension brackets are constructed of 16 s.w.g. pressings; welded to the inboard face of each is a double-flanged gusset that sits on the top of the longitudinal and is bolted thereto.

Towards the rear of the frame, on the inner faces of the main members, are two horizontal brackets, of channel-section and tapering in depth, that form the anchorages for the diaphragm type support for the nose of the final-drive unit. These brackets also carry conduits for the hand brake actuating cables. To form anchorages for the upper ends of the rear dampers, channel-section struts, of 14 s.w.g. material, are welded to the rear cross member; they are inclined outward and slightly forward, and are braced by almost vertical, inward facing channels. The lower portions of the flanges of these channels are profiled to permit them to be welded to the outer and upper faces of the longitudinals.

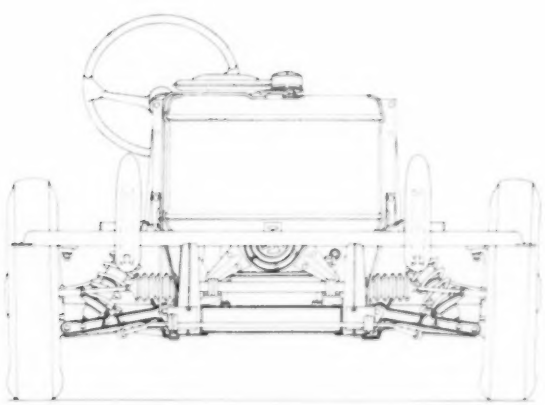
Both side members, which extend only between the wheels, are carried on outriggers. Each, together with its three outriggers, has a plan form approximating to a letter E, but with a rearward inclination of the leading arm and a slight forward inclination of that at the rear. The side member is of channel section, 1¼ in wide × 2¼ in deep; its thickness is 17 s.w.g, as also is that of the three arms, each of which tapers in depth from the inboard to the outboard end. Each front outrigger is of channel section, with rearward extending flanges, 2 in wide. At the inboard end, the web is profiled to permit the flanges to overlap the top and bottom faces of the longitudinal. There is a continuous weld all round the outside of the joint. The outboard end fits into the side rail channel to which it is lap welded at top and bottom.

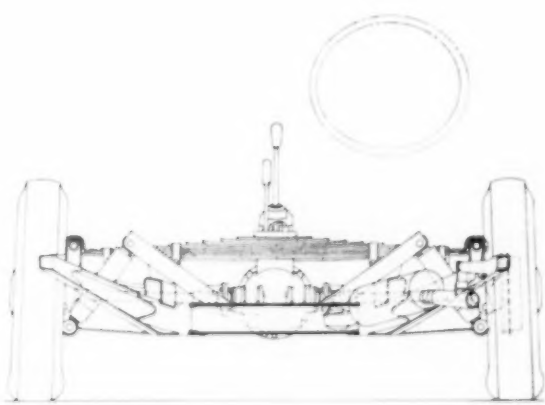
A top-hat section, with an overall width of 3·63 in, forms each of the intermediate outriggers. The method of attachment to the longitudinals is similar to that of the front ones, but the joint is reinforced by an overlapping plate welded to the undersides of the arm and the longitudinal. Both rear outriggers are of channel section, having the same flange width and method of attachment as the front arms. In this case, however, the flanges of the channels extend forward, and the strength of each member is increased by the addition of a closing plate, which is welded to both flanges. To permit a neat installation of the fuel and brake system pipelines, the vertical webs of all the arms are relieved at their inboard ends: the relief is at mid-depth and is in the form of a short slot with a semicircular end. Since the frame is dip painted, all the box sections are pierced at various points, so that thorough penetration of paint is assured.

**Bodywork**

When the Herald was introduced last year, there was a choice of two types of body—a four-seat saloon and a fixed-head coupé, available at extra cost with an occasional rear seat for two children. Earlier this year, a convertible model was added to the range; it has an occasional rear seat in which two adults can be carried. All three bodies, which are virtually the same below the waistline, are of the two-door type and were styled by Giovanni Michelotti, in conjunction with Vignale, the well known Italian specialist coachbuilders.

The Italian influence in the styling is pronounced, mainly in the impression of length and lowness of build, and in the angularity of the roof treatment. A continuous, slightly convex line runs from the top of the headlamp cowl to the peak of the rear wing, and is underlined by a narrow stainless steel beading. Below the beading is a full-length





moulded line that, by dipping towards the front of the car, gives a reversed *lancéolé* effect.

To provide good forward visibility, the bonnet line falls slightly between the front wings. At the rear, the boot lid has a similar slope, so the wings rise above it, as shallow tail fins. Where a two-tone colour scheme is employed, the roof and the body sides, below the moulded line, are in the darker colour; the upper portions of the sides are in the lighter shade, as are the tops of the bonnet and boot. Not everyone appears to like the reversal of the *lancéolé* motif, or the colour distribution, but the effect is certainly distinctive.

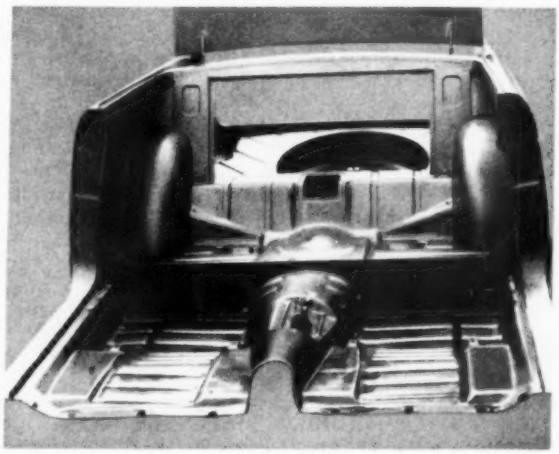
There are several other characteristic touches in the styling. For example, the headlamp bezels are not circular, but are slightly squared; they are mounted with a backward rake and have a cutaway profile that forms a cowl over the upper part of the lens. This profile is matched at the rear, where the peaks of the wings project over the lamp groups, which have a forward rake. At the front, the bumper overriders flank the radiator grille, whereas those at the rear form downward extensions of the lamp groups.

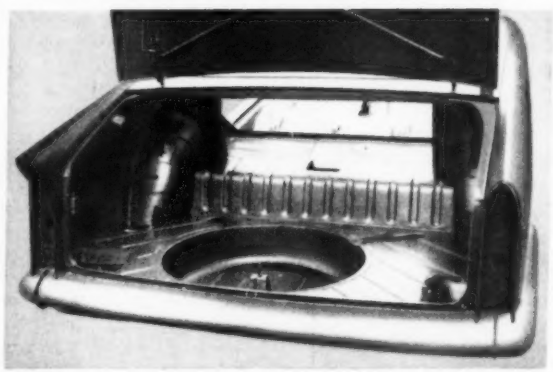
Externally, the most marked difference between the three bodies, below window level, is in the length of the rear decking ahead of the boot lid. This decking is shortest on the saloon and longest on the coupé. The lower portion of the body consists of three major assemblies, and there are six additional units common to all three versions. Of the three assemblies, the largest is the rear one, which extends from the rear valance to the leading edges of the front seats and embodies the transmission tunnel. Ahead of it is the intermediate assembly comprising the dash structure, the front portion of the floor, and the windscreen frame.

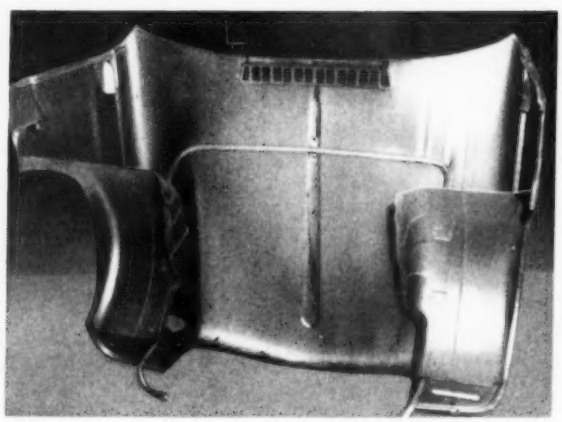
The third major assembly is that of the bonnet and front wings; it is hinged to the cross tube at the front of the chassis frame. This assembly does not carry the radiator grille, which is mounted on the front valance, a separate pressing blending the nose into the underside of the car. The other additional units are the body sills, below the door openings, the two doors themselves and the lid of the boot.

Whereas the convertible model has an orthodox folding head, of plastics-coated fabric, the saloon and coupé have bolted-on steel roof units. The roof panel of the saloon is relatively flat and, viewed in cross-section, its mid-portion is slightly stepped down, to increase the stiffness. On this model, there are large quarter lights; since the mildly raked and curved rear light is virtually of full width, the quarter pillars are unusually slim, a feature that gives an excellent backward field of vision.

In contrast, the coupé head has a more longitudinally







*Four views illustrating constructional details of the body. Above right: The rear portion, seen from ahead, showing the transmission tunnel and the vertical heelboard pressing at the front of the seat pan. Right: Rear view of the same portion; the recessed spare wheel position and the bridge between the wheel arches are worthy of note. Below: The mid-section, consisting of the dash structure, windscreen frame and part of the floor. Below right: Rigidity of the frontal assembly is obtained by mounting it on a tubular frame of approximately horseshoe shape*

curved roof panel, unglazed quarters having a pronounced angle at the junction with the roof, and a steeply raked rear light, which again is very wide. Its top panel, as on the other model, is stepped. When the head of the convertible is closed, its lines are intermediate between those of the saloon and the coupé. The rear light is of the three-piece type, in order to provide a considerable wrap-round and thus to minimize the visual obstruction inherent in this body style.

As has already been stated, the various units of the body are bolted to the chassis frame and to each other. In each unit, however, the joints are effected by welding, in the normal manner. The styling is such that the pressings embody little deep drawing, so tooling costs have been kept relatively low. Full use is made of the available boot space, by recessing the spare wheel into the floor and by mounting the fuel tank vertically at the left-hand side, behind the wheel arch.

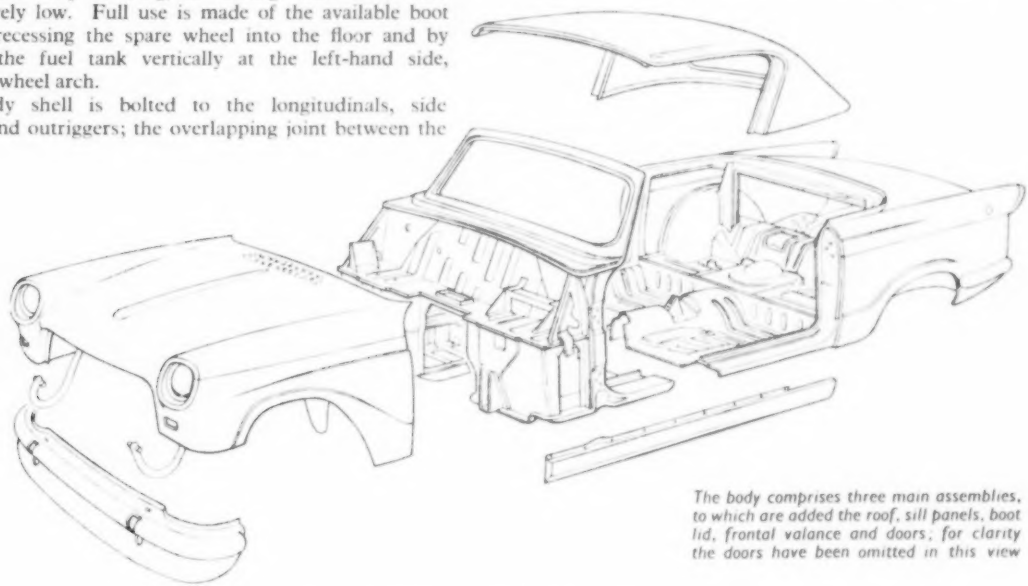
The body shell is bolted to the longitudinals, side members and outriggers; the overlapping joint between the middle and rear sections is above the intermediate outriggers. Insulation between the body and the frame is provided by large diameter rubber-and-canvas pads. One of these is fitted between the two structures at each of the 18 attachment points, and the holding-down bolts pass through them. All these bolts have a diameter of $\frac{3}{8}$ in. Most of the body pressings are of 20 s.w.g. steel sheet, though heavier gauge material is used at certain points for reinforcement. The three main assemblies are shown in the accompanying illustrations, which give a good idea of the extensive fluting that is employed to give the necessary stiffness and resistance to resonant vibration.

There are two features of the rear portion of the shell that contribute markedly to its rigidity. The first of these is the fact that the transmission tunnel is integral with the floor and is welded to the heelboard. Also, there is a deep tunnel extending laterally between the wheel arches, to clear the rear suspension. This tunnel is welded to the wheel arches, which in turn are joined to the side panels. It is an extension of the seat pan, and its rear edge is welded to the boot floor. The leading edge of the seat pan portion is lipped upward and is spot welded to the heelboard.

Each wheel arch comprises an inboard and an outboard pressing; the two are joined, along out-turned peripheral flanges, in the vertical, longitudinal plane. To simplify the presswork, each side panel is in three parts, joined along inwardly turned flanges. The largest panel embraces most of the wheel opening and extends from the door shut pillar to the rear of the car. Its joint with the upper panel, which also extends from the pillar to the rear, is slightly stepped to form part of the longitudinal moulded line along the side.

Ahead of the wheel opening, the body sill member is bolted to the lower edge of the side panel. The sill extends forward to the front wheel opening and is attached to the frame as well as to the intermediate and rear sections of the body. Aft of the rear wheel opening, the third pressing is welded on below the main panel. It incorporates the wrap-round portion of the rear valance, which serves as a bumper, and a plate is welded across the inner face of this portion to complete a D section.

Since the boot lid opening reaches almost to the floor—to facilitate loading and unloading—there is no rear skirt panel above the valance, which is a 20 s.w.g. pressing of domed section and is welded on each side to one of the lower rear side panels. The joints are in the vertical longitudinal plane and are concealed by the over-riders, which are mounted on the extremities of the rear extensions of the frame longitudinals, to give adequate resistance to impact.

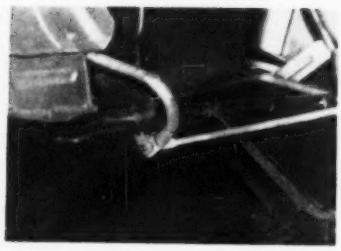


*The body comprises three main assemblies, to which are added the roof, sill panels, boot lid, frontal valance and doors; for clarity the doors have been omitted in this view*

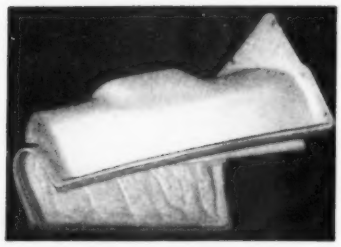
A deeply dished, circular pan forms the spare wheel stowage tray. It is lipped outward round its periphery, the flange being spot welded to the edge of the corresponding hole in the boot floor, which is reinforced to withstand the load. Although this mounting of the spare wheel has the advantage of not encroaching on the luggage space, it does mean that a full boot must be almost emptied for access to the wheel. This, however, is by no means an uncommon feature of modern cars, but fortunately most of them are rarely driven with the boot full.

The stiffening effect on the transverse tunnel over the final drive unit makes it unnecessary to have a bulkhead behind the rear seat. As a result, if the squab is hinged forward, the boot can be reached from inside the car, or unusually long articles can be carried. The rectangular opening behind the squab is bounded at the sides by almost vertical supports, which have, in effect, an elongated top-hat section. These support pressings are welded to the transverse tunnel, the wheel arches and the box section leading edge of the rear decking. The exact positions of the squab supports and their angle of inclination are varied to suit the different lengths of rear decking of the three body styles.

There is a considerable inward curvature at the top of the side panels. Inboard of this curvature, and ahead of the rear decking, the edges of the panels are turned downward and then outward, to form top rails of L section. Each



*Above: The ends of the bonnet supporting tube are linered and flattened to form the pivots of the assembly. Right: Little boot space is taken up by the slim fuel tank, the capacity of which is 7 gallons*



*Above: A moulding of resin-impregnated fibre covers the gearbox and is attached to the floor and the dash. To its lower surface is stapled a thick layer of sound insulating material in a polythene casing*

door shut pillar is constructed of three pressings. One forms the face against which the door closes; it is welded to the turned-in edge of the side panel and has a lip at its inboard edge to which is welded the pressing that forms the inner face of the pillar. The third portion is of Z section, and one of its flanges, extending rearward, is welded to the outboard face of the second pressing, adjacent to its rear edge. Two internal gussets reinforce the almost complete box section obtained by this construction. The lateral rigidity of each pillar is increased by a triangular gusset between its inboard face and the heelboard.

The floor of the assembly is divided longitudinally by the transmission tunnel, and is on two levels, connected by a ramp. On the forward, higher level are mounted the front seats; the lower portions comprise foot wells for the rear seat passengers, and the ramps serve as toe boards. The wells are recessed between the intermediate and rear transverse arms of the outrigger E units of the chassis frame. Because the transmission tunnel has to span the frame longitudinals as well as the propeller shaft, its section widens towards the rear, though not sufficiently to encroach appreciably on foot room. On the tunnel is a bracket that carries the handbrake lever and ratchet.

For adequate stiffness, the rear face of the boot lid is indented over much of its area; on this indented portion is mounted the rear number plate. The almost flat top of the lid is braced internally by two tubular stays. These are disposed in a cruciform arrangement, and their leading ends are attached to the lid by the bolts securing the hinges. The hinges are of the external type, and both the lid and the rear decking are locally reinforced at their attachments.

At the joint between the rear and intermediate assemblies of the body shell, the floor of the intermediate assembly overlaps that of the other. A stuck-on strip of rubber serves as a seal between the two floor portions, which are clamped together and to the frame by eight bolts. The intermediate assembly, which is constructed of a number of pressings, embodies the foot wells for the front seat occupants. These wells fit into the spaces between the leading and intermediate arms of the outrigger portions of the frame; by lowering the effective floor level, they play a valuable part in securing a low roof line without undesirable restriction of head room.

Rigidity of this portion of the body structure is obtained by two means. In the first place, the door hinge pillars are of box section, as also is the windscreen frame, the pillars of which form continuations of the door pillars; the scuttle rail of the screen is also of box section. Additionally, the upper portion of the dash is in the form of a channel, with flanges of unequal depth, the deeper being underneath. The upper flange is the scuttle panel, which has a peripheral stiffening lip, and the lower is welded to the left-hand and right-hand combined front and side pressings of the dash structure; these pressings, of approximately L shape in plan view, are also welded to the lower portions of the door pillars.

In the scuttle panel is the fresh-air intake for the heater. The collecting tunnel below this intake is welded to the web of the dash channel, which it helps to stiffen. At each end of this channel, an embossed triangular gusset pressing braces the angle between the bottom flange and the web. The rigidity of the web is further increased by the fact that its inclination changes from a rearward rake, over much of its length, to vertical at each end. A bracket for the attachment to the frame is welded to the leading face of each side and front pressing of the dash. These faces are swaged to help to prevent resonant vibration, and the lower edge of each pressing is lipped.

To the inboard edges of the two foot wells is bolted the deep cover over the gearbox: this cover, which is also bolted to the dash structure, is a moulding of compressed wood fibre, impregnated with resin. It embodies a small tray for oddments in its upper face. For sound absorption, the interior of the moulding carries a thick layer of mineral wool, contained in a bag of polythene and stapled in position. Sponge rubber beading strip of channel section, stuck to the moulding where necessary, forms an effective seal between it and the floor, dash and transmission tunnel.

On both the closed bodies, the roof unit is of relatively simple construction. To provide a robust attachment to the rear decking, the bottom rail at the rear is of box section. In the case of the saloon, because of the slenderness of the quarter pillars, the edge of the rear light opening is stiffened by means of a double joggle. These pillars are, in effect, of top-hat section and are braced by two internal gusset straps. Another strap forms a stay between the roof panel and the top of the rear light opening, and there is additional reinforcement at each side where the upper part of the door pillar is attached.

The rear quarters of the coupé roof have recently been modified to improve the appearance and the drainage of rain water. Originally, since the gutter followed the shape of the side lights, its rear end on each side was on the leading edge of the quarter panel, which blended without an obvious break into the top panel. Now, however, the rear portions of the gutter are formed on the upper edges of the quarter panels, and so have an inclination similar to that of the rear light, which they flank. Additionally, a series of

horizontal flutes is pressed into the quarter panels, to relieve their flatness.

On the saloon, each door pillar extension, which is of box section, is secured by two screws to the top of the body, and by a further two to the roof unit. To provide a seal, rubber beading is fitted between the front of the roof and the head rail, and between the rear of the roof and the body. At each end of the roof there are three holding down bolts. The roof attachment method is similar on the coupé, except that the two screws on each side secure the quarter panels, instead of the pillars, to the body sides. It is of interest that, to facilitate trimming and the embodiment of two-tone colour schemes, the roof units are not fitted until after painting.

A conventional boxed construction is employed for the wide doors. Their leading edges and the body pillars are reinforced in the region of the hinges. A triangular ventilation panel is mounted in front of the main window of each door. These main windows wind down completely, in the usual manner, but they are frameless and, when closed, seat in an extruded rubber beading.

As has already been explained, the bonnet and front wings form a single unit, hinged at the front to give access to the engine. To avoid excessive flexibility, without the use of complex gusseting, the assembly is mounted on a steel tube of 1 in diameter and 20 s.w.g. thickness, reinforced at each end by an 18 s.w.g. liner. This tube, the almost horseshoe shape of which is clearly shown in one of the illustrations, forms a bridge between the bonnet top and the wheel arches, and its extremities carry the hinge pivots.

The shell of the bonnet comprises three pressings, the top and the two sides, which are joined along inwardly turned flanges. On the outside, these joints are concealed by the stainless steel strips; the longitudinal moulded lines are swaged in these panels, as they are also on the doors. The headlamp openings are incorporated in the top panel, which also forms the crowns of the wings. Each wheel arch comprises two domed pressings, inboard and outboard, and has an inwardly turned lip that is welded to a corresponding lip round the wheel opening. The reinforcing tube is bolted at three points to the inboard pressing of each arch, as well as to the top panel.

At the front, the structure is reinforced in several ways. The bottom edges, from the openings for the wheels to that for the radiator grille, are made into box sections by additional small pressings, and another horizontal pressing at each side connects the leading end of the wheel arch to the box section. In addition, the grille opening is braced to the wheel arch on each side by a small pressing that is welded to the flanged edge of the opening and bolted to a bracket on the arch.

The rear edge of each side panel of the bonnet is strengthened by a welded-on member of channel section. On each side, between the rear edge and the wheel opening, is mounted the recessed lever of one of the two over-centre type fasteners that secure the bonnet in the closed position. These fasteners engage catches on the sides of the dash structure. The bonnet is raised from the front by means of a handle in the middle of the top face. A counterbalance spring minimizes the effort needed to raise this relatively heavy assembly, and no support stay is normally necessary because of the over-centre travel, which is limited by a bracket on the front cross tube. However, a stay rod is provided as a safety measure, for use should the bonnet be opened in a high wind or when the vehicle is parked on an incline.

A very simple design of hinge has been adopted for the bonnet. To each side of the bumper over-rider attachment brackets is bolted a small shackle plate. Each end of the bonnet support tube is flattened and drilled to take a short tube, which is welded in position. This tube fits between the two shackle plates, and the shouldered pivot bolt passes through all three. A tubular stay, connecting the pivot bolt to the suspension bracket, prevents longitudinal movement of the shackle.

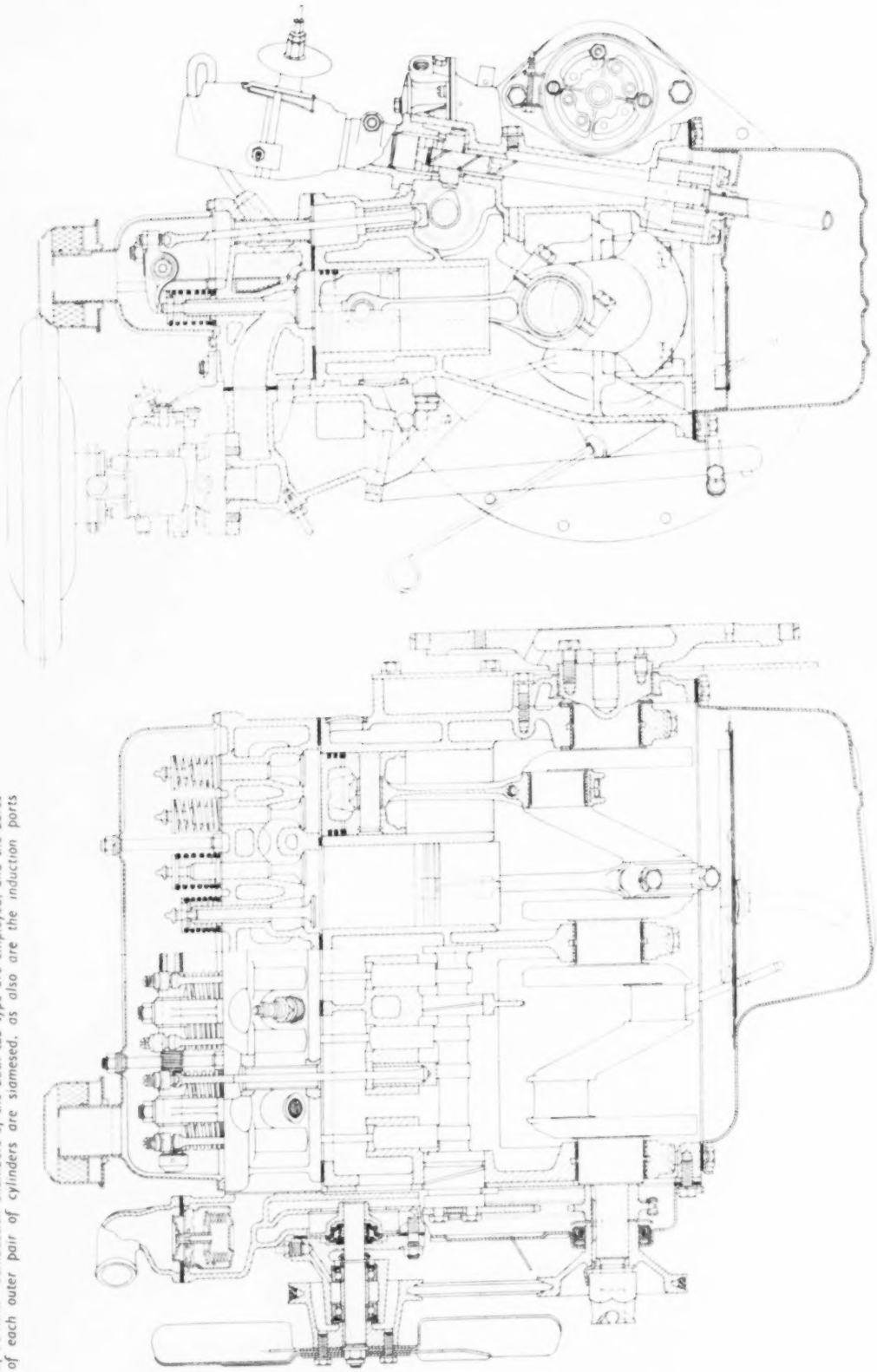
The remaining portion of the body is the frontal valance that carries the radiator grille. It is bolted to the bumper tube, and the over-rider brackets protrude through it. The pressing has a swaged contour that gives the impression of a separate, external bumper and, because of the small clearance between it and the tube, little damage could occur to it before any impact were taken by the tube.

**Engine**

Two versions of the 948 $cm^3$, four-cylinder engine are in production for the Herald. The first, fitted as standard to the saloon, has one carburettor and a medium compression ratio; the other, which is installed in the other two models and is available in the saloon at extra cost, has two carburettors, a higher compression ratio and a camshaft of rather more sporting characteristics.

Since the basic engine is generally similar, apart from

*A praiseworthy aspect of the design is the accessibility of the engine when the bonnet assembly is raised. The power unit illustrated is that fitted as standard to the saloon model; it features one Solex carburettor, and the makers quote a gross power output of 38 b.h.p. at 4,500 r.p.m.*



Longitudinal and cross sectional views of the Herald engine, in single-carburettor form. The unit has a swept volume of 948 cm³, derived from a bore of 63 mm and a stroke of 76 mm. Combustion chambers of the bath tub type are employed, and the bores of each outer pair of cylinders are siamesed, as also are the induction ports

having a larger bore, to the Standard Eight 803 cm³ unit described in the June 1954 issue of *Automobile Engineer*, no detailed analysis is necessary here. Instead, reference will be made to the more important points of difference between the two sizes of engine, and between the two versions fitted to the Herald. The increase in swept volume has been effected by enlarging the bore from 58 to 63 mm, without external alteration to the block casting; however, it has been necessary to siamese the cylinders of the front and rear pairs to get an adequate thickness of wall. As a result of the larger bore, the stroke : bore ratio has come down from 1·31 : 1 to 1·21 : 1.

Both sizes of engine have largely similar, cast iron cylinder heads, with bath tub type combustion chambers and parallel, vertical valves. The exhaust ports of all the cylinders are separate, but the inlet ports of cylinders 1 and 2, and 3 and 4, are siamesed. A small increase in port cross-sectional areas accompanied the enlargement of the swept volume.

The smaller unit originally had a compression ratio of 7·0 : 1, later raised to 7·5 : 1 and then to 8·25 : 1, whereas the standard ratios for the current 948 cm³ engines are respectively 8·0 : 1 and 8·5 : 1. The earlier changes necessitated modifications to the height of the top face of the block above the crankshaft axis, in order to obtain the correct clearance volumes. For the Herald, because of the necessity of catering for fuel octane ratings varying, throughout the world, from 70 to 101, three cylinder heads are specified; these differ in respect of the combustion chamber depth. Since there are alternative cylinder head gaskets, of copper-asbestos or steel, a choice of three compression ratios can be offered on each engine. For the single-carburettor unit, the ratios are 7·0 : 1, 7·5 : 1 or 8·0 : 1, and for the other version they are 7·5 : 1, 8·0 : 1 or 8·5 : 1.

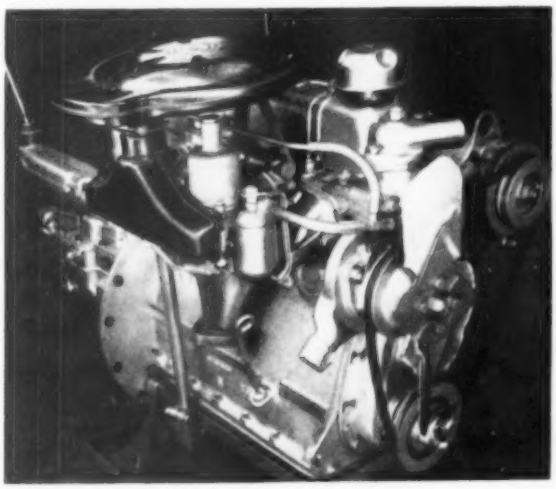
The standard version of the Herald engine has a single Solex B28ZIC-2 downdraught carburettor. This has a choke diameter of 20 mm, whereas an 18 mm choke was employed on the 803 cm³ unit. On the higher-performance variant, two S.U. H1 horizontal carburettors are fitted. They have 1¼ in diameter throttle bodies and are connected by sheet metal ducting, of inverted-T form, to a common air filter and silencer.

A combined inlet and exhaust manifold, of cast iron, is featured on the single-carburettor engine. It differs from that of the smaller-capacity engine in having larger passages, and in having less dip between the port branches of the inlet portion. This change was made to reduce the hot-spot area between the two portions of the manifold, and has resulted in a reduction in the height of the riser. The two-carburettor engine has separate manifolds, the inlet of aluminium and the exhaust of cast iron. It would, perhaps, be more accurate to describe the inlet manifold as a carburettor adaptor unit incorporating a balance pipe. The pipe portion has buffer ends and is situated above the flanges; cored passages connect the balance passage to the port branches.

Since the basic 948 cm³ engine is required to give a higher specific output than did the 803 cm³ unit, its valve lift is slightly greater and the opening envelopes are longer. The development process has been carried further in the two-carburettor engine, as can be seen from the comparative figures given in the accompanying table. Double valve springs are fitted to this second version, to ensure satisfactory operation at the higher r.p.m. of which it is capable.

It will be noted from this table that a greater ignition advance is used with the higher compression ratio than with the lower. Other things being equal, it is normal, of course, for combustion to be accelerated by an increase in compression ratio. However, the apparent discrepancy is accounted for by the fact that the advance settings quoted are those required for full power at the respective, different peak engine speeds. To avoid over-advance at low engine speeds, both the centrifugal and vacuum controls of the two-carburettor unit have different characteristics from those of the other engine.

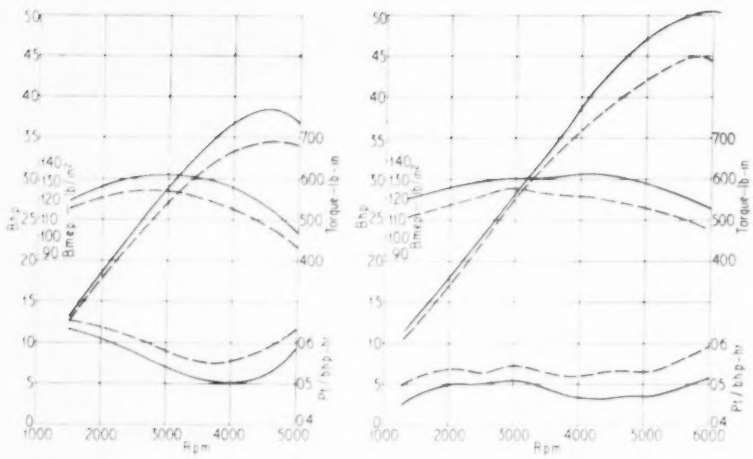
Reproduced herewith are performance curves for both



*Above: Whereas the inlet and the exhaust manifolds are combined on the standard, single-carburettor unit, they are separate components on the two-carburettor engine shown here, which has S.U. H1 instruments*

*Left: A table of valve gear and other data for the Standard Eight 803 cm³ unit and the two versions of the Herald engine evolved from it. The successive increases in lift and timing overlap are noteworthy*

| | 803 cm³ engine | 948 cm³ engine | |
|---|---|---|---|
| | | One carburettor | Two carburettors |
| Valve head diameter— | | | |
| inlet | 1·12 in | 1·18 in | 1·18 in |
| exhaust | 0·99 in | 1·06 in | 1·06 in |
| Valve lift, inlet and exhaust | 0·255 in | 0·280 in | 0·312 in |
| Inlet valve opens, b.t.d.c. | 10 deg | 12 deg | 18 deg |
| Inlet valve closes, a.b.d.c. | 50 deg | 52 deg | 58 deg |
| Exhaust valve opens, b.b.d.c. | 50 deg | 52 deg | 58 deg |
| Exhaust valve closes, a.t.d.c. | 10 deg | 12 deg | 18 deg |
| Spring rate—outer | 148 lb in | 150 lb in | 150 lb in |
| inner | — | — | 28·75 lb in |
| Valve crash speed— | | | |
| theoretical | 6,440 r.p.m. | 6,020 r.p.m. | 6,630 r.p.m. |
| Ignition timing, b.t.d.c. | 10 deg | 6½ deg (7:1) | 10 deg (7·5:1) |
| | | 10 deg (8:1) | 12 deg (8·5:1) |




*Graphs of gross and net b.h.p., torque and b.m.e.p. and specific fuel consumption for the two engines, measured under the SAE conditions; the left-hand graph, of course, is for the variant with one carburettor*

### ENGINE SPECIFICATION

*Four cylinders. Bore and stroke, 63 mm and 76 mm. Swept volume, 948 cm³. Single-carburettor and two-carburettor versions; data for the latter given in parenthesis where applicable. Maximum b.h.p. (gross SAE), 38·5 at 4,500 r.p.m. (50·5 at 6,000 r.p.m.). Maximum b.m.e.p., 134 lbf/in² at 2,750 r.p.m. (133 lbf/in² at 4,200 r.p.m.). Maximum torque, 615 lb-in at 2,750 r.p.m. (610 lb-in at 4,200 r.p.m.). Compression ratio, 8·0 : 1 (8·5 : 1); alternatives detailed in text. Three-bearing, counterbalanced crankshaft. Chain driven camshaft. Vertical, in-line overhead valves actuated by push rods and rockers. Bath tub type combustion chambers in cast iron cylinder head. Siamesed pairs of inlet ports. Solex B28ZIC-2 downdraught carburettor, with 20 mm diameter choke (two S.U. H1 semi-downdraught carburettors, with 1⅛ in diameter throttle barrels; balance pipe unit fitted between carburettors and head). Oil-wetted, gauze type air filter. AC mechanical fuel pump. Dry weight, with air filter, starter motor, dynamo and flywheel, 273 lb.*

the Herald engines, measured under the SAE specified conditions. The two-carburettor version, with an 8·5 : 1 compression ratio, has a higher power output throughout the speed range than has the single-carburettor unit with an 8 : 1 ratio. As would be expected, however, its improved breathing has a greater effect at higher rotational speeds, and the usable speed range is extended upward by about 1,500 r.p.m.

The speed at which maximum torque and b.m.e.p. are developed is higher on the two-carburettor engine but, as a result of the greater valve overlap and its adverse effect on volumentric efficiency at other than high speeds, the peak values are almost the same as those of the single-carburettor version. The noticeable kink in the curves of the more highly tuned engine is apparently due to an unfavourable resonance effect in the induction system at about 3,500 r.p.m. This unit has the better specific fuel consumption of the two, owing to its higher compression ratio: the minimum consumption of 0·463 pt/b.h.p-hr, at 4,300 r.p.m, is satisfactorily low, and the curve lies below 0·5 pt/b.h.p-hr over much of the speed range.

As on the smaller-capacity Standard Eight unit, the ratio of connecting rod length : stroke of the Herald engine is 1·925 : 1, a normal figure. At maximum gross power, the mean piston speeds of the single- and two-carburettor version are respectively 2,245 and 2,990 ft/min. The ratios of maximum torque : torque at maximum b.h.p. are 1·14 : 1 and 1·15 : 1 respectively, while the corresponding ratios of speed at maximum torque : speed at maximum power are 0·61 : 1 and 0·70 : 1. In terms of b.h.p/litre and b.h.p/in² of piston area, the respective output figures for the two engines are 40·6 and 53·3, and 1·99 and 2·62. A dry weight of 273 lb is quoted for both, the figure being inclusive of air filter, starter motor, dynamo and flywheel; the power : weight ratios are, therefore, 0·141 and 0·185 b.h.p/lb.

The methods employed of mounting the power unit in the chassis frame are orthodox. At the front, the crankcase is supported on the longitudinals by two sandwich type rubber units. The rear mounting, on the gearbox extension casting, comprises two rubber bobbins; it will be described in greater detail later. Since the propeller shaft is of fixed length, the natural axis of oscillation of the power unit on its mountings passes through the geometrical centre of the shaft's front universal joint.

In this connection, it is of interest that the type of mountings and their location were selected after practical tests. The company's experience has shown that, because of the influence of the frame on vibrational characteristics, the theoretical solution—based on the dynamics of the engine—is not necessarily the best in practice. It has been found that, within quite wide limits, variations in the lateral inclination of the front mountings have little bearing on their efficiency; consequently, they have been arranged on the Herald without any such inclination, in order to facilitate the installation and removal of the power unit.

## Standard for Speedometers

SPEEDOMETERS and odometers for motor vehicles are covered by the new British Standard 3190 : 1960. Part I of the Standard, which deals with the instruments for cars and light vans, is necessarily somewhat restricted because the wide and rapidly changing variety of the equipment makes standardization difficult. However, it embraces the drive system and the accuracy, protection, installation and general performance of the instruments for these types of vehicle, and there is a section on tests.

Part 2 concerns speedometers and odometers for heavy commercial vehicles, in which field greater standardization can be attained; consequently, the requirements laid down are more comprehensive. Sections are included on the drive, installation, types of enclosure, mounting and overall dimensions, parallax, dial presentation, rotation and deflection, insulation resistance, accuracy, performance in varying atmospheric conditions, index stability and identification marking. Type and routine tests are also covered. Copies of B.S. 3190:1960 are obtainable from the British Standards Institution, Sales Branch, 2, Park Street, London, W.1. The price is 6s per copy, postage extra to non-subscribers.

# Design Office Planning

## *A Methodical Approach to the Progressing of a Long Term Project Through the Design Office*

E. RAYMOND BROOKE, M.I.E.E., A.M.I.E.D.

PRODUCTION control, time and motion study and similar techniques have made it relatively simple to predict and progress a job through the workshops. Unfortunately, these methods do not lend themselves to progressing design or drawing work, because many of the man-hours involved are completely dependent upon events that may or may not take place at a date well beyond that when the estimate is made. Two examples will illustrate this point.

A rather elaborate mechanical indexing mechanism, to position a product, was called for in the specification of a special purpose machine, and a rough design layout was prepared to meet this requirement; the estimated design and detail time required was of the order of 400 man-hours. However, three months later, when the time came to consider this part of the design fully, it was realized that, owing to a modification made in the meantime by the customer, the whole requirement could be met by a simple electronic unit reading impulses from the product itself. This was a fortunate estimating error, as time was saved, but things do not usually work out so well, as the second example will show.

In this case, a punched tape reading unit was being designed and a simple scanning method using photocells was envisaged; the design and details were expected to be complete in seven weeks. After the design had been completed and detailing was well advanced, some components of the equipment were made and tested. The results were disappointing in every way, and prolonged experiment began. A designer's output was completely absorbed for many weeks during the experimental work and the requirement was eventually solved by the use of different cells, a redesigned optical system, a new tape material and special electronic units giving temperature compensation. In this instance, the drawing estimate proved to be about one fifth of the time actually needed.

It is difficult to see how any method could have been used to make either of these estimates more accurate than they appeared to be at the time they were made. Indeed, even if a crystal ball were available at the start of a project and the true time and cost involved could be clearly seen, it is more than likely that the customer would at once cancel the entire project. To this extent, hope often produces results which certainty would have denied.

### A better method

If a positive order for the work has been placed, it becomes the duty of the chief designer to revise his estimate at reasonably frequent intervals. Logic tells us that each estimate should be more accurate than the previous one, because experience just gained on the actual job in hand can be applied in increasing measure at each review. Frequent estimates enable the trend of progress to be measured. However, on a project that lasts, say three years, it is just as easy to be hopelessly wrong when trying to predict the end of the work after the first eighteen months as it was after six months, unless, however, steps are taken to measure and display the trends in a graphical manner, which can be easily comprehended by non-technical persons as well. This method has the special advantage that it enables some of the responsibility for an accurate prediction of the end of the project to be shared by directors and the customer. Their combined experience and knowledge enables them to form an independent judgment of progress from the charts, a fact which often ensures harmonious relationships throughout the project. For this reason alone, the time spent on preparing the charts is easily justified.

### Project phases

All extensive design projects follow a recognizable pattern having three main divisions or phases. These are:

1. *Exploratory phase*
   - (a) Statement of the problem
   - (b) Analysis of the problem
   - (c) Suggested solutions and alternatives, with design sketches
   - (d) Calculations and experiments of a basic nature
   - (e) Analysis of results and proposed designs, leading to
   - (f) Preliminary specifications and recommendations.
2. *Design phase*
   - (a) Rough design layouts, including alternatives, for first model
   - (b) Combination of units and development of overall scheme
   - (c) Design layouts for deriving details and logical design of electronics
   - (d) Detail draughting of experimental equipment
   - (e) Manufacture and testing of experimental equipment
   - (f) Design layouts proper. Appearance design considerations
   - (g) Detail draughting, schematics, parts lists and modifications
   - (h) Checking G.A's and checking throughout.
3. *Model, or hardware phase*
   - (a) Manufacture and assembly of units
   - (b) Testing of units
   - (c) Assembly of complete equipment
   - (d) Test, performance evaluation
   - (e) Modify and re-test
   - (f) Re-asssess and re-wire specification for production prototype.

The foregoing statement of the pattern is categorical and well defined, but in any practical case the phases overlap one another by about 70 per cent. In an endeavour to save time and to show tangible results, it is common practice to start manufacture as soon as details of any of the units become available, even though they have not been fully checked. This practice is of questionable value, and, if carried too far, can lead to great waste of effort. It is much cheaper to modify drawings than to modify the hardware and the drawings.

Generally, each of the phases is handled by a different group of people: phase 1 by the engineers, phase 2 by the design and drawing staff, and phase 3 by the production and

research staff. Of course, there are many exceptions to this generalisation and, indeed, the interchange of ideas and information between the groups is very valuable to all concerned. The chief designer or chief engineer who is responsible for the formulation and execution of the project must at all times be ready to follow the trouble course wherever it may lead.

The scope of this article is limited in the main to phase 2 and it is assumed that phase 1 is sufficiently complete to allow 2(a), that is, the rough design layouts, to be made.

**Preparation of charts**

The first step is to break down the project into separate sections, or units, which are as self-contained as possible. Each of these units is then analysed as far as is possible at this early stage; separate estimates of design and detail man-hours are made, allowance being made also for the following factors:

1. Parts lists
2. Checking
3. Modifications
4. Holidays
5. Illness
6. Printing and issuing

A contingency allowance of at least 15 per cent should be added to the total of both design and detail man-hours.

All the units should be listed below one another; and, entered under two columns headed "Design" and "Detail", there should be the appropriate estimated man-weeks. Design and detail time can now be totalled, and under a further column, the figures for "Percentage of Total D.O. Time" can be entered. These figures show the relationship between the drawing time required for the different units and they give a balanced picture of the project as a whole. It is not important that the estimated time may fall short of the true time taken, as long as the figures represent, with at least some degree of accuracy, the proportion of time required for each unit relative to the next. The table may look as follows:

| | *Man-weeks, design* | *Man-weeks, detail* | *D.O. time per unit* | *Percentage of total D.O. time* |
|---|---|---|---|---|
| Unit A | 90 | 182 | 272 | 17½ |
| Unit B | 44 | 72 | 116 | 7½ |
| Unit C | 49 | 83 | 132 | 8½ |
| Unit D | 98 | 162 | 260 | 16½ |
| Unit E | 153 | 251 | 404 | 26 |
| Unit F | 120 | 256 | 376 | 24 |
| Total D.O. Time: (man-weeks) | | | 1,560 | 100 |

It is improbable that each of the units can be worked upon simultaneously, as usually, the design of two or three of them will have to be near completion before the others can be usefully tackled. Even if this were not so, the limitation of manpower normally present would itself prevent simultaneous working. For instance, six designers would be needed to start upon the six units listed above and it is unlikely that in an office of, say, twenty people six designers of the right calibre would be available. Therefore, it is necessary for the unit sequence to be decided upon soon after the man-hour estimate has been made. From this, a sequence chart, such as the one shown in Fig. 1, can be

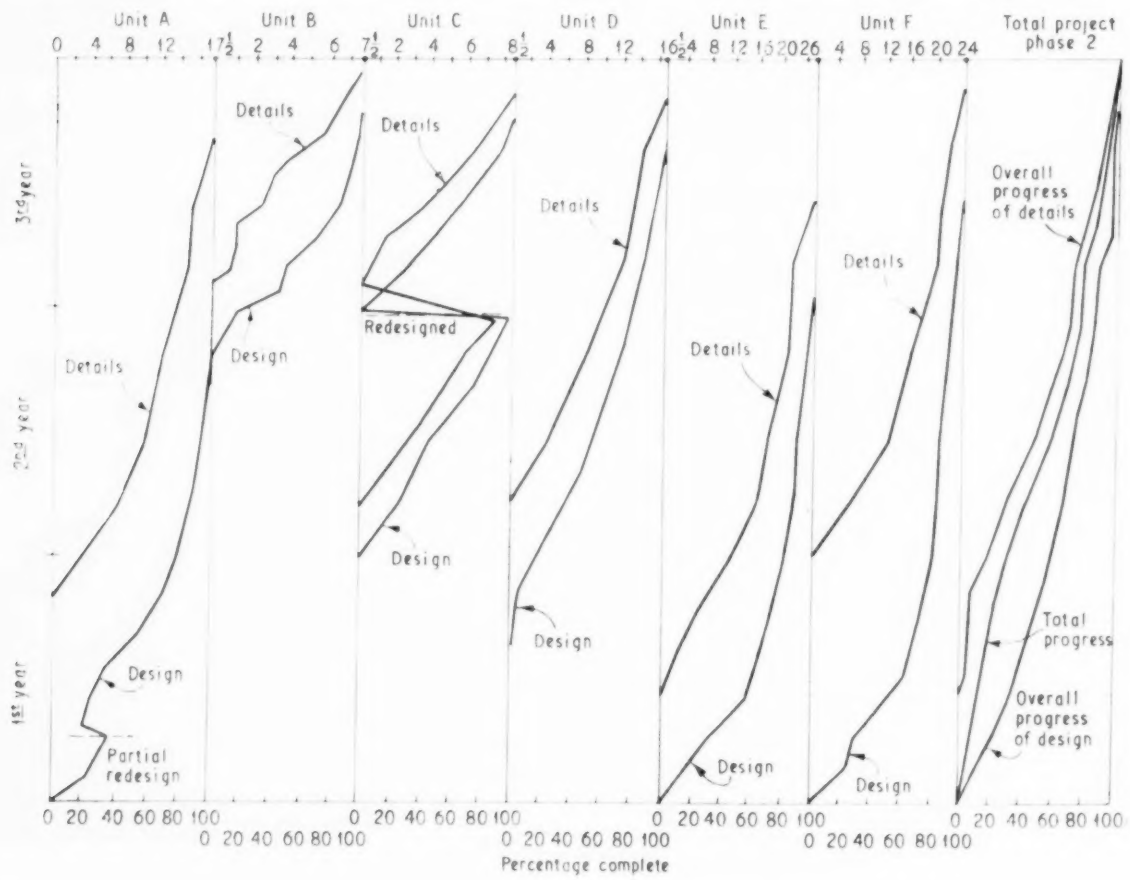
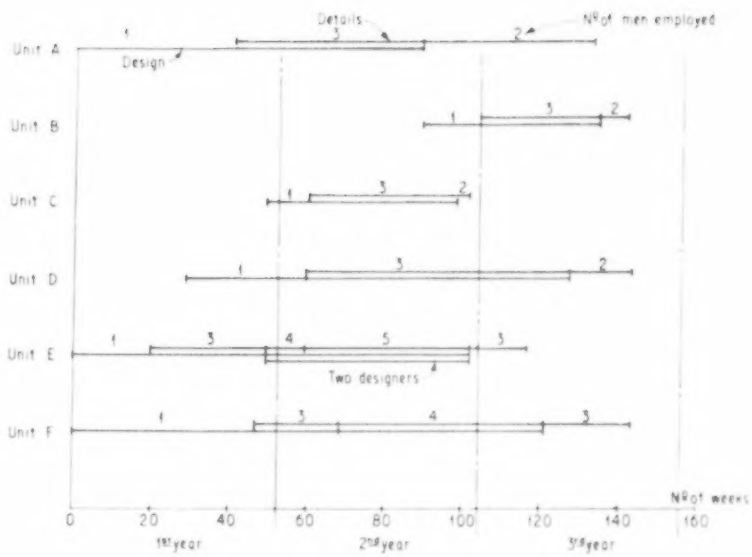


*Fig. 1. Right: A typical arrangement of a sequence chart for drawing office work*

*Fig. 2. Below, right: This is a form of chart recommended to show the progress of the design work for an individual unit*

*Fig. 3. Below, left: These charts show the progress of six units, and the overall and total progress curves for a three year task*




derived. This shows which particular designer will tackle a given unit; how long he will take, according to the estimate; how many detail draughtsmen will assist him; when he will be free to start another unit; and when the detail draughtsmen will be free also.

When this chart is complete, it will show the entire programme for the office, to the completion of the project. It will also show when it is necessary to engage extra staff and where it appears best to apply them. Unfortunately, as anyone who has tried this will know, events have a way of choosing their own course and, owing to the kind of occurrences described in the first paragraphs, it is very unlikely indeed that the ideal programme laid down on this chart will be followed in practice. Nevertheless, it is necessary to prepare it at this stage in order to make possible the next step, which is that of laying out the progress charts.

## The progress charts

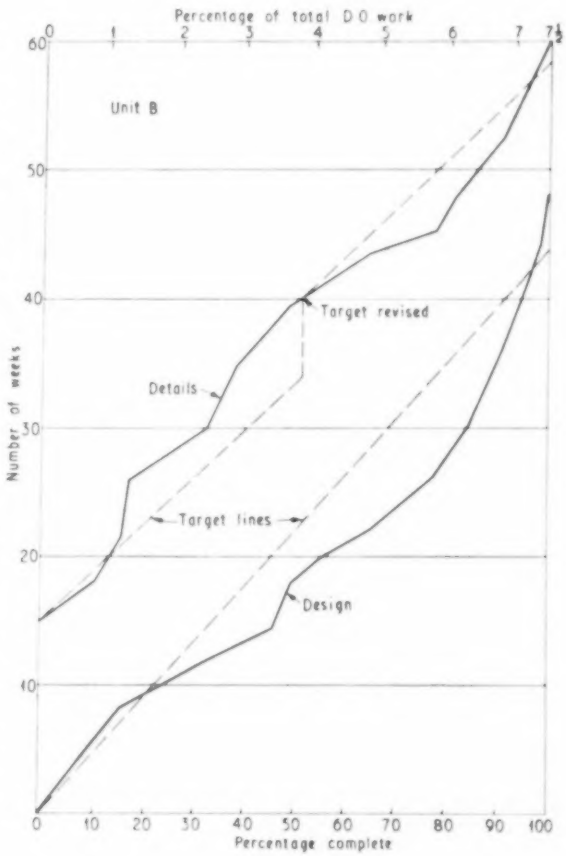
A chart must now be prepared for each unit. In Fig. 2 is shown a recommended form: the vertical ordinates are of time—a year is shown in the example—and the horizontal ordinates are of percentage complete. It is convenient to show time vertically, so that the charts can be constructed side by side. Another advantage of this layout is that notes referring to, for example, changes in design or additional manpower, can be written opposite a date without the risk of introducing ambiguity.

Consider now how the curve on Fig. 2 is to be derived and plotted. Suppose the design work of unit B starts on 1st January. After two weeks, it is desired to know the percentage complete, and this can be judged by the chief designer in three ways: (1) by asking the designer for his opinion or guess; (2) by examining the work done against what is known to be required, and making an independent judgment; and (3) by a proportional calculation based upon a linear interpretation of the estimate made earlier. Method (3) is not a judgment based upon fact, of course, but together with the other two methods it is possible for a figure to be arrived at which has some measure of truth in it; this judgment of percentage complete is then plotted against the appropriate date. The process is repeated at about fortnightly intervals, and it will be found that as the work proceeds these judgments can be made with an increasing sureness and accuracy. By now, the trend of progress will be reasonably clearly shown and extrapolations can be made to predict the finish of this part of the work.

## Target lines and conversion scale

The original estimate of the time required to complete the design of unit B can be plotted on this chart, as shown by the dotted line, known as a *target line*, in Fig. 2. If the true progress curve crosses this line, it is a clear indication that the target is unlikely to be met. This can be used as a guide for overtime working or increased effort but, in general, these measures are not very effective in design matters, and the best practical step is to revise the target date to allow for the trend being shown. If, however, the target line for detailing is crossed by the progress curve, the use of additional draughtsmen is a practical step that can often be taken to make the target again attainable.

The scale 0 to 100 per cent of design completeness represents, in the example under consideration, a progress of



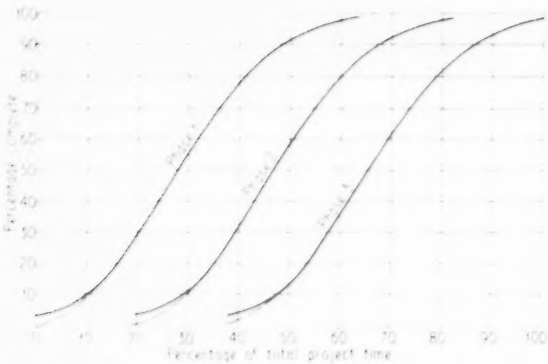


*Fig. 5. Typical logistic curves showing the overlap of the three phases*

0 to 7½ per cent of the total estimated drawing time. This scale can be added at the top of the chart, as shown in Fig. 2. It enables the progress of any unit to be read off directly in terms relating to the total D.O. work.

**Derivation of total progress curve**

Shown in Fig. 3 are typical curves for the six units, A to F. The effect of setbacks and complete redesign are shown for units A and C respectively. Use of colours for the individual graphs is desirable, and a suggested convention is red for design, blue for detail and yellow for target lines. The seventh chart shows the overall progress of the work in the D.O, and it is, of course, plotted week by week as the job proceeds. Each point is derived by summating the progress of the six units along a common date line, the value being read, in each case, from the conversion scale at the top of each chart. This is done separately for both the design and the detail work. *A total progress curve* is derived from the proportional average of the figures for design and detail, and this can be plotted separately. Total progress figures are particularly useful for quoting at meetings; it gives a measure of satisfaction to be able to quote a numerical answer to the inevitable question about progress. But when such a figure is given, it is only fair that it should be accompanied by a cautionary statement drawing attention to the non-linearity of the curve from which it is derived.

It is usually the case that each unit will have to be broken down into sub-units. Therefore, it is necessary to make a progress chart for each sub-unit and derive the curves of design and detail progress for the unit concerned by the method already described for the overall progress curves.

**The Pearl-Reed logistic curve**

In Fig. 4 is shown the total progress curve plotted more conventionally, with time as the horizontal axis. In America a great many completed projects have been analysed, and these show that the total progress of large projects, such as computers and calculators, conforms to a very well defined pattern. The curve of their progress follows closely the logistic growth curves common to population growth and the growth of living organisms. These are of the form:

$$F(t) = \frac{K}{1 + e^{a + bt + ct^2 + dt^3}}$$

The dotted curve in Fig. 4, read against the axes 0 to 100 per cent, represents a dimensionless plot of a Pearl-Reed curve typical of a large project, such as a computer. A good deal of evidence indicates that the progress of the individual phases follows a similar curve; Fig. 5, based on this assumption, shows how the three phases are likely to overlap in a typical case; the data are taken from a project having combined mechanical, electro-mechanical and electronic problems. Phases of equal duration are shown.

Evidence from many different sources shows that the pattern of progress varies little, whatever the nature of the project, and the reason for this is as follows. At the start of a project of this kind there is a multitude of problems requiring solution. Two or three people tackle the basic ones first and then extra staff are called upon to develop their solutions; as they do this, they disclose new problems, and a cumulative process is started. The man-hours incurred per week usually reach a maximum in the design and drafting stage and then, as the problems are successively solved, the man-hours per week decline. If the project is sufficiently large, requiring, say, six or more men for a year at least, the variations of a random nature effectively offset one another, and the rise and fall of effort tends to follow the natural laws of growth applying to organic processes.

**Prediction**

If a project is of at least the minimum size mentioned in the foregoing, certain empirical rules of prediction can be applied at definable points throughout the job. These are:

1. It is assumed that the man-hours per week of phases 1 and 2 are being regularly recorded. At the date when the man-hours per week of phase 2 rise to and equal the value of those devoted to phase 1 upon that same date, a check point is reached.
   Let the time from the effective start of the project to this date be M months. Then:

   *Phase 2—Design and detail*

   Time from start of project to end of phase 2 ≃ 2·5 M months.

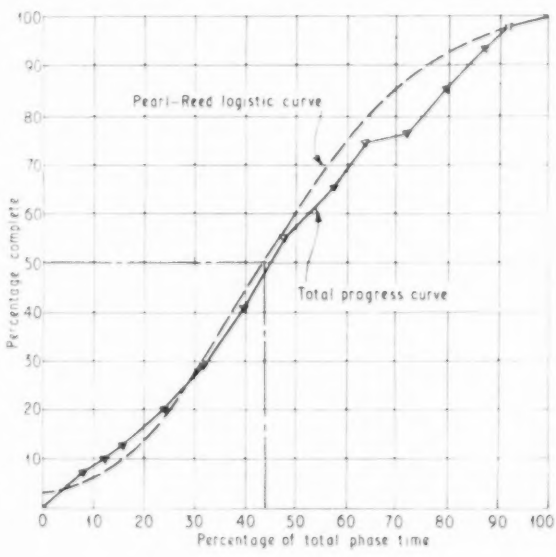
   Note: The end of a phase is considered to be reached when it is about 97 per cent complete. Absolute finality may not be attained until many months later.

   *Phase 3—Prototype*

   Time from start of project to end of phase 3 ≃ 3·25 M months.

2. From the weekly plot of the total progress curve, the time taken from the start of phase 2 to the point of 50 per cent completeness of phase 2 can be read off. From Fig. 4, it can be seen that this point corresponds

*Fig. 4. Total progress curves, predicted and actual, on a time basis*



to only 44 per cent of the duration of phase 2. Then:

*Phase 2*

Duration of phase 2 $\simeq \frac{10}{44} \times$ months required for 50 per cent completion.

*Phase 3*

Time from start of phase 2 to end of phase 3 $\simeq 1{\cdot}4 \times$ duration of phase 2.

**Conclusion**

It cannot be expected that an exact science can be formulated to deal with a subject so intangible as prediction but, if the graphical methods described are assiduously carried out throughout a long project, an increasingly realistic understanding of job progress will result. The empirical rules given can be usefully applied as the check points are reached, and they will, at any rate, prevent wildly optimistic predictions from being strongly held and followed later by long periods of disillusionment, disappointment and even financial loss.

A basic assumption implied in their use is that the problem as a whole permits of a practical solution with known techniques. Should this assumption be incorrect, it is obvious that no methods of prediction would help. Similarly, problems of an order of complexity approaching this will also cause the predictions to be over-optimistic. Early in phase 1, it must be possible for the designers to see through all the major problems if the methods of prediction described are to be confidently applied.

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## Fifty Years of Component Manufacture

(CONTINUED FROM PAGE 325 OF OUR AUGUST ISSUE)

THE derivation of the initials E.N.V, in the name E.N.V. Engineering Co. Ltd, is interesting. This firm was originally formed in 1910, under the name E.N.V. Motor Syndicate Ltd, and its registered offices were in Sheffield. The organization was set up to manufacture a V-eight aero-engine, which was designed by an Englishman but made initially in Paris, where it was known as *le moteur en-V*. The last three letters form the initials of the English company.

In January 1910, the Hythe Road plant, at Willesden, London, N.W.10, was established, and it is now the registered office of the company. By April of that year, the first engines were being built. However, the aero-engine business soon deteriorated, but the equipment that the company had designed and built for producing camshafts was turned to good account: it is believed that E.N.V. was at that time the only firm grinding the profiles of cams. During the 1914-18 war, the firm manufactured camshafts for aero- and tank-engines, and also carried out special work such as cylinder grinding. In 1919, the company's registered name was changed to E.N.V. Motors Ltd, with registered offices at Hythe Road. They made straight-tooth bevel gears and differentials for early post-war cars and commercial vehicles but, because they were noisy, gears of this type soon fell out of favour and, in later designs, were replaced by spiral bevel gears. In 1919, E.N.V. installed some of the first Gleason spiral bevel gear cutting machines in this country.

The post-war boom brought many small firms into the motor manufacturing business and, because they could not afford to lay down specialized plant themselves, they came to E.N.V. for their gears. One by one they faded from the scene, and with them went much of E.N.V.'s business. However, a turning point came when in the early 1920s W. R. Morris placed large contracts for spiral bevels and differentials. This enabled E.N.V. to lay the foundations of the quantity production plant the company has today.

Gleason hypoid gear generators were imported and installed in the Hythe Road plant in about 1925 and, so far as is known, they were the first of their type to be used in Europe. The following year began an association with Gustaf Larson and Assai Gabrielson, who were then making plans for producing in Sweden a passenger car, now the well known Volvo. In 1928, the firm became a public company under its present name, E.N.V. Engineering Co. Ltd.

During World War II, the company designed and developed gun control gears and mechanisms for tanks, and also transmissions for fighting vehicles; other work undertaken included the production of final drive units for road vehicles, gears for high-speed launches and motor torpedo boats, as well as a multitude of special work. It also continued to supply bevel type reduction gears, and other gears, for Bristol aero-engines, and these were produced in a separate factory a few miles from the main plant.

After the war, as a result of the expansion and rationalization of the motor industry, the large manufacturers of cars set up their own gear manufacturing plants. However, the commercial vehicle manufacturing business expanded, as also did the tractor, earth moving and agricultural machinery industries, so there was still plenty of scope for the application of the company's equipment and experience. A significant step was taken when E.N.V. joined with the Eaton Manufacturing Co, of Cleveland, U.S.A, and Rubery Owen and Co. Ltd, Darlaston, to form Eaton Axles Ltd. E.N.V. installed plants to manufacture the two-speed mechanism of the Eaton axles. In 1950, a branch factory was opened at Aycliffe, Co. Durham. Initially, this plant was established to manufacture the Eaton axles and special mechanisms for fighting vehicles. However, it has grown rapidly and now produces a wide range of gears for a variety of applications.

The British Piston Ring Co. Ltd., of Coventry, has actually been in existence for over 51 years, since the company, first known as The British Chuck and Tool Co., was established in March 1909. Its founder, W. A. Oubridge, became interested in the manufacture of piston rings during the following year. In 1911, a new limited liability company was formed under the title of The British Chuck and Piston Ring Co. Ltd, and the present name was adopted in 1919. Since that time, the company has expanded enormously, has acquired another firm and formed various subsidiaries, and has itself, together with Hepworth and Grandage Ltd. and Wellworthy Ltd, become a member of Associated Engineering Ltd. Through the years, the range of products has been extended: first pistons, then gudgeon pins, cylinder liners and tappets went into production, to be followed by sodium-cooled valves for aero-engines. Among the more recently introduced products are stainless iron cylinder inserts, ported liners for two-stroke engines, diesel engine swirl chambers, bimetallic, air-cooled cylinders and sintered metal components.

It is the opinion of the company that progress in the design and production of pistons and rings has played a highly important part in engine development. For example, the change from cast iron to aluminium alloy as a piston material at once enabled engine speeds to be considerably increased, because of the consequent reduction in inertia forces. The evolution of satisfactory diecasting methods, too, brought about an outstanding diminution of production times. Improvements in piston ring materials and production methods have not only permitted a reduction in the number, width and weight of the rings per piston, but have made possible the manufacture of these components in the almost fantastic quantities necessary today.—*To be continued.*

*The new Shell Research, engine lubricants laboratory block at Thornton is an impressive and pleasing building. In the background is the Stanlow refinery*

# Research on Engine Lubricants

## *New Laboratory for Engine Tests at Shell's Thornton Research Centre; Extensive Use Made of Pallet Type Test Beds*

THERE can be few fields of competitive activity in which research plays a more vital role than it does in the petroleum industry. As is well known, the world's current consumption of fuels, lubricants and other petroleum products is enormous, and all the major companies are constantly striving to increase their share of the market. To do so, they obviously must try to offer products superior to those of their rivals, and such superiority can be achieved only by intensive research.

Petroleum research can be divided into three main categories: the first of these covers exploration and production, the second deals with the development and performance of the products, and the third with processing. Because of the wide variety of interests involved, the Royal Dutch Shell Group has a total of sixteen laboratories situated in Europe and North America. The Thornton Research Centre, near Chester, is concerned only with oil products, and its work covers all applications of fuels, lubricants and bitumen.

The work at Thornton can be regarded as having two aspects. In the first place, it is concerned with the short-term improvement of existing products to meet performance requirements that become ever more stringent. The second, and more important, function is the long-term one of evolving new products to meet future demands. Since the aim is at looking five or even ten years ahead, such projects necessitate a world-wide intelligence service and the careful sifting and analysis of the information received.

When an entirely new product is envisaged at Thornton, the first essential, clearly, is for the requirement to be precisely stated. Then, on this basis, several potential products are formulated, and samples prepared. These pass through chemical, physical and engine or rig evaluations; the initial tests eliminate the less promising products, and work continues on the more favourable ones. In the case of an engine lubricant, for example, reliable evaluation is possible only if the actual operating conditions are reproduced within the laboratory, where they can be closely controlled.

From this it follows that tests in power units play a vital part in the work of the Engine Lubricants Division at Thornton. The building in which, until recently, all the test beds of this division were housed was originally built, during the war, for a different purpose. In consequence, not only were the working conditions inside it hardly as pleasant as are expected in modern times, but the overcrowding as a result of the increasing scope of the work was not conducive to optimum efficiency. Plans for a new engine test laboratory were therefore put in hand about two years ago. The building is now finished and some of it is already in use.

### Layout of the laboratory

As can be seen from the accompanying illustration, the plan of the new laboratory building is in the shape of a letter T. The various offices and a chemical laboratory are housed in a two-storey block comprising the bar of the T, the leg of which is formed by the engine test block. This block, which measures approximately 250 ft × 45 ft, is of curtain-wall construction and is divided into six sections. Alongside, at its far end, is the lubricating oil store and the fuel distribution panel, fed from a tank system nearby. From one end of the office block, a covered way leads laterally to a single-storey building containing a store, a

solvent washing section and the engine services workshop. In this last-mentioned building, the engines are prepared for test and subsequently stripped for examination.

Between the office block and the test block is a common room, in which the test staff can do writing or technical reading in quiet surroundings. To avoid any encroachment on the useful floor space, a covered way of the lean-to type runs right down one side of the test block. It is glazed on its open side, for protection from the weather.

Accommodated in the section of the test block that is nearest to the offices will be the motor-generator sets and switchgear for all swinging-frame electric dynamometers, as well as the house sets for the direct current supply to the laboratory and the lead-acid batteries used for emergency lighting, control gear and engine ignition systems. At the time of writing, this electrical equipment was in the process of installation, and water brakes or eddy current dynamometers were in use on the engines under test. Some fan brakes were employed in the old building, but these will not be transferred because of their noise.

In the next section of the building, 16 deep beds are being installed for testing larger types of automotive engine and units such as the Caterpillar single-cylinder engines, which would otherwise transmit excessive vibration to their surroundings. These beds will be described in greater detail later. They are arranged in four transverse banks of four, and there are two control cabins; each cabin caters for two of the banks and is placed between them. The walls and ceiling of the bay are sound-proofed, as also are the control cabins. In each cabin are four control stations, each of which overlooks two engines, through a large window. The instrument panels, controls and recording equipment for each engine are arranged on the appropriate side of the window. It is noteworthy that all the panels and control systems in the block are constructed by the Thornton staff.

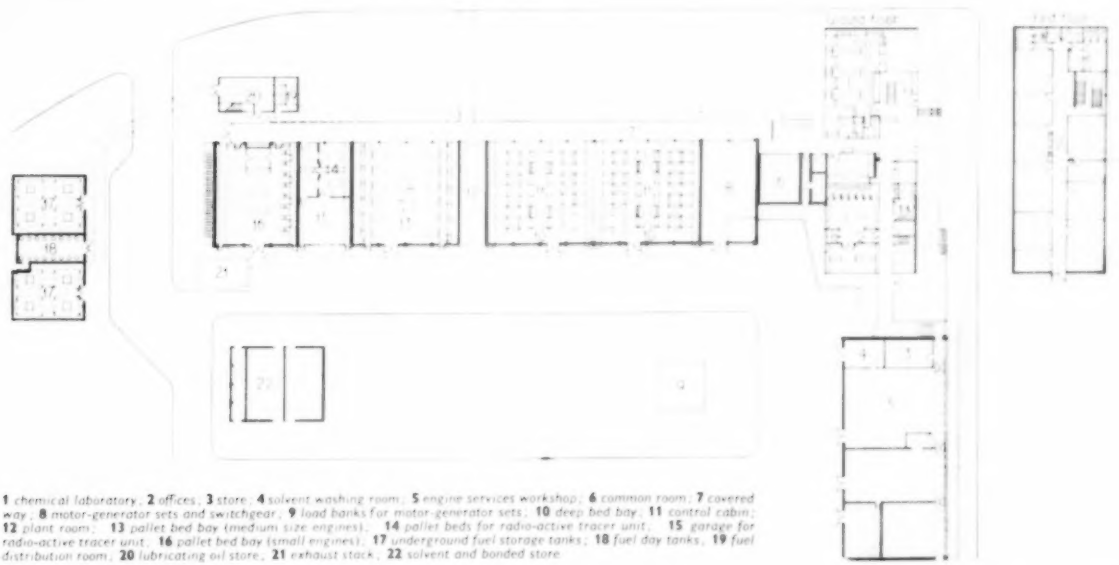
The next main bay of the building has provision for 12 beds, in two rows of six, for test work on medium size engines, both petrol and diesel. All these beds are of the standard pallet type developed by the Research Centre as a means of saving time and giving greater flexibility of programming. The pallets themselves will be described later in this article, but it is appropriate at this juncture to outline their background. It had been found that, in the older laboratories, the use of permanent beds was resulting in considerable loss of time in those tests where frequent changes of engine were necessary. With that set-up, clearly, one engine had to be uncoupled and removed before the next one could be installed.

On the other hand, where a pallet system is used, a number of engines and dynamometers can be prepared in advance, each on its own pallet, in a separate department. When a change is required, all that is necessary is to uncouple the flexible pipes and leads of the various services, wheel the first pallet out of the way, wheel in the next, and recouple the services. The first pallets to be tried soon proved their merit, and so a standard design was evolved; in due course, part of the old engine lubricants laboratory, which had been used for other purposes, was converted to house eleven pallet beds. These beds were installed within four months of the stripping out of the building. An important secondary advantage of the changeover to pallet beds was that it greatly facilitated the subsequent move to the new building.

Between this pallet bed bay and the previously described deep bed one is the plant room, in which is the cooler for the main cooling water system. This room also contains two water softeners, all water fed to engines being softened to avoid scaling of jackets and pipes. Other equipment in it includes air compressors, for the supply to certain instruments and controls, and the switchgear for the ventilation system and other services required in the building.

The fifth bay of the block is reserved for the work of the radio-active tracer unit which, of necessity, has to be isolated from the rest of the laboratory. It is divided into two by a longitudinal wall, and in one section are two of the standard pallet test beds. The other section forms a garage for the various test cars employed by the unit.

In the final bay is a line of smaller pallets carrying Petter single-cylinder engines, which are used for specification tests and the screening of the various lubricants proposed



**1** chemical laboratory; **2** offices; **3** store; **4** solvent washing room; **5** engine services workshop; **6** common room; **7** covered way; **8** motor-generator sets and switchgear; **9** load banks for motor-generator sets; **10** deep bed bay; **11** control cabin; **12** plant room; **13** pallet bed bay (medium size engines); **14** pallet beds for radio-active tracer unit; **15** garage for radio-active tracer unit; **16** pallet bed bay (small engines); **17** underground fuel storage tanks; **18** fuel day tanks; **19** fuel distribution room; **20** lubricating oil store; **21** exhaust stack; **22** solvent and bonded store

*A reproduction of the plan of the new laboratory building, showing the division into bays, and the position of the test beds and other equipment*

for a given project. These engines, of which eight were installed at the time of writing, are frequently modified to suit the particular purposes of the tests. The most common modification is the replacement of the standard cylinder block, head and side valve assembly by another, to give an overhead valve gear. For this purpose, a head cut from a normal car engine component is prepared, and is mounted on a specially cast cylinder block; suitable push rods are made to enable the existing tappets to actuate the overhead rockers. If necessary, too, a special camshaft can be fitted. In this way, the effects of variables such as combustion chamber design, compression ratio and tappet loading can be studied without departing from the standard bottom half.

In this bay will also be accommodated various two-stroke engines which at the time of writing were still in the old building. In addition, there will be several pallet beds of an intermediate size for automotive engines of under 1 litre swept volume, which will be used for accelerated cold sludging tests. In these tests, jacketed sumps and tappet covers—fabricated from standard parts—are fitted and are constantly fed with cold water.

*The various services, except the fuel, are led along a full-length plenum tunnel that lies beneath the covered way at the side of the building. To facilitate any maintenance work that may be necessary, the tunnel is of ample height and width, and it has adequate illumination*

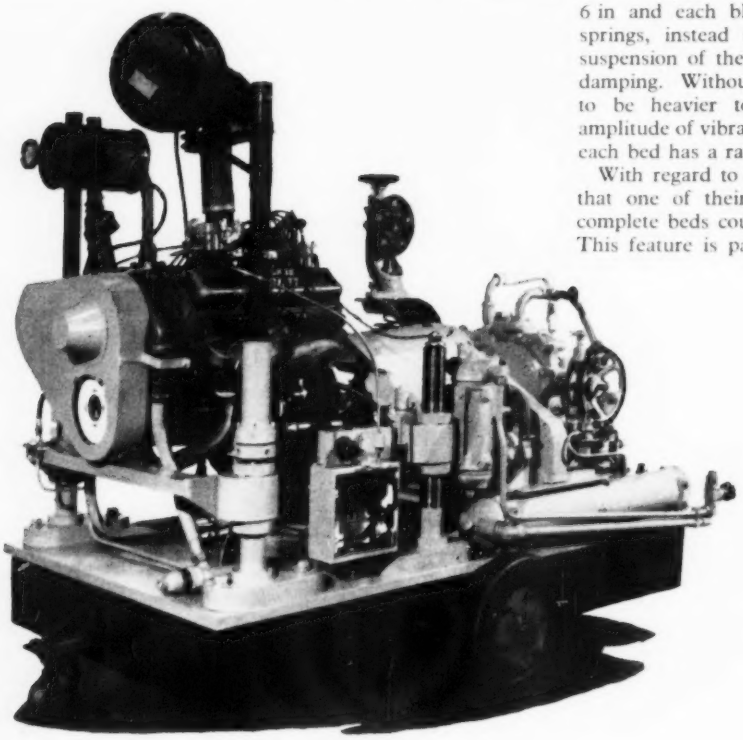
**Types of test bed**

All the deep beds in the new laboratory are of the sprung type, in which there is no direct contact with the surrounding floor. Other methods of insulation have been tried in the past but it has been found that, wherever there is the possibility of severe vibration, the sprung bed is the most satisfactory. Fourteen of the beds are of one design and the remaining two of another, larger, pattern. In the case of the smaller beds, the concrete block on which the engine is mounted weighs 15½ tons—an unusually high figure for a bed having floor plan dimensions of 4 ft 6 in square.

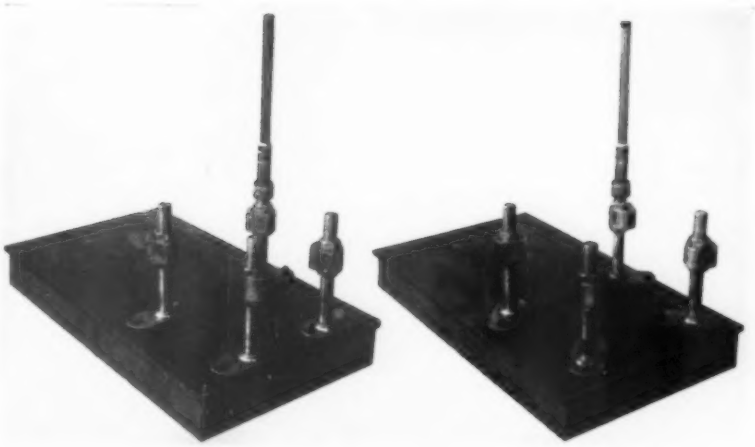
Four pairs of coil springs, each spring having a rate of 4 ton/in, support the block. An ingenious method has been adopted to obtain a high volume, and therefore weight, without recourse to an undesirably deep pit: in cross section, the block is of inverted-T shape, each arm of the T forming part of the service trench between the block and its neighbour. On top of the concrete block is mounted a cast iron bed plate in which are four T-slots, to facilitate the installation of engines of various sizes and types. The dynamometer is separately mounted on a steel plate, bolted at six points to the floor. If a change of dynamometer is required, it is therefore only necessary to disconnect the services and to undo these six bolts, whereupon the machine and its base can be removed as a unit.

The two larger beds are of a design generally similar to the others, but their floor plan dimensions are 9 ft 9 in × 5 ft 6 in and each block weighs 33 tons. Semi-elliptic leaf springs, instead of coil springs, are employed for the suspension of the block, because of their greater inherent damping. Without this damping, each bed would have had to be heavier to obtain a satisfactorily low dynamic amplitude of vibration. Each of the eight springs supporting each bed has a rate of 1·88 ton/in.

With regard to the pallet beds, it was mentioned earlier that one of their advantages was the ease with which complete beds could be changed during a test programme. This feature is particularly valuable in the fuels division,



*A large American V-eight engine, coupled to a water brake, installed on one of the standard pallet test beds now widely used at Thornton. For moving the complete unit from place to place, the bed is jacked up and then wheels are fitted. The engine's cooling fan and its drive are shielded, to avoid any injury to the testing staff*



*Right: Two of the standard pallet beds, showing the alternative positions of the pillar feet; each pillar is offset from the middle of the foot. The attachment blocks shown here on the pillars are being superseded by the later type mentioned in the text: the newer block is a cube, and the hole is asymmetrically positioned in it*

*Left: One of the two banks of pallet beds for tests on medium size multi-cylinder engines. Each pallet stands on four thick blocks of cork, to minimize transmitted vibration, and above it is a collecting hood for the removal of heated air. These hoods are of divided construction, and can be hinged up to improve engine access*

where it may be necessary to run a number of different types of engine consecutively for relatively brief periods. In work on lubricants, however, although many of the tests may again be of short duration, they are usually carried out on a number of engines of the same type. It follows that a semi-permanent pallet installation is practicable, the engines being changed—as on a normal bed—and not the pallet.

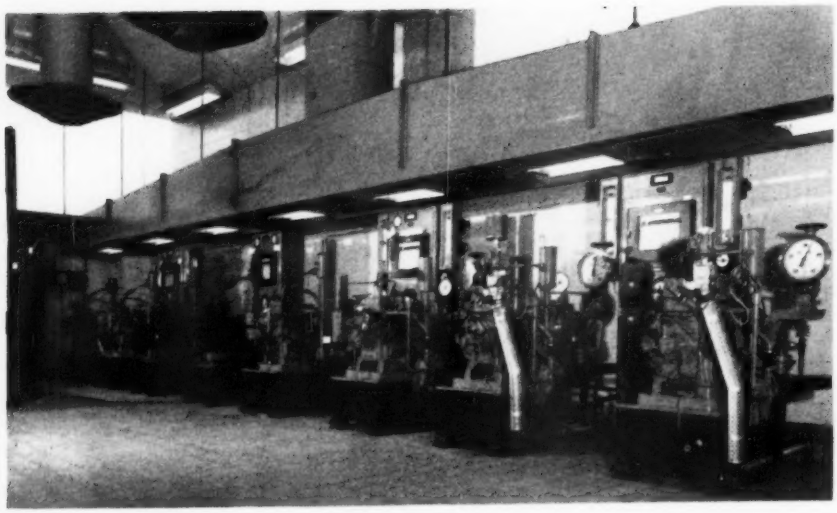
This semi-permanent scheme is used for the twelve standard pallet beds in the second testing bay. For speedy replacement, it is obviously desirable for the engine to be kept as accessible as possible. Consequently, the various services are rigidly connected to a bridge on the pallet; this bridge is disposed to the rear of the engine, to which flexible pipes and leads are taken from the bridge.

The pallet itself consists of a rectangular steel top plate attached to a channel-section frame. A system of engine mountings has been evolved that enables units of a wide range of sizes to be satisfactorily aligned with the dynamometer which, of course, is also mounted on the pallet. The top plate measures 6 ft 4 in long × 3 ft 6 in wide × 1 in thick, whereas the frame is of 8 × 3 in channel, $\frac{1}{4}$ in thick; the bare weight of the pallet is 1,000 lb. In the middle of each side of the frame is a pad, to which wheels can be attached for transportation, those at the front and rear being of the castoring type. To enable the wheels to be fitted, the bed is jacked up.

In the top plate are various taped holes for the attachment of the four threaded pillars that form the basis of the engine mounting. Each pillar has a diameter of 2 in and is carried on a substantial foot, held down by two bolts. To assist in providing the necessary universality of mounting, the pillar is situated towards one end of the foot.

On to the pillar is screwed a block, which is secured in the desired position by a locknut above and below it. The hole through the block is so positioned that its axis is at a different distance from each of the four vertical faces, each of which has four tapped holes. In the case of larger engines, the four bearer brackets are bolted directly to the appropriate faces of the blocks. For smaller units, however, each pair of pillars is spanned by a horizontal tubular rail, secured to the blocks by split clamps; on the rails are mounted additional split clamps that form the bearer brackets. To keep the installation as neat as possible, the rails are used to pipe the coolant to and from the engine. For the carriage of ancillary equipment, extension pillars can be screwed on to the main pillars.

Each of the bearer brackets carries a conical rubber and metal bonded flexible mounting unit. Several types of mountings are available, differing in respect of the grade of rubber, to suit various weights of engine; in general, the torsional flexibility of the mounting is lower than it would



*In the end bay of the building is a line of 8 Petters single-cylinder engines, each of which is mounted on a small type of pallet bed. Two adjacent units share a free-standing control and instrument panel, and the water brakes stand on trestles*

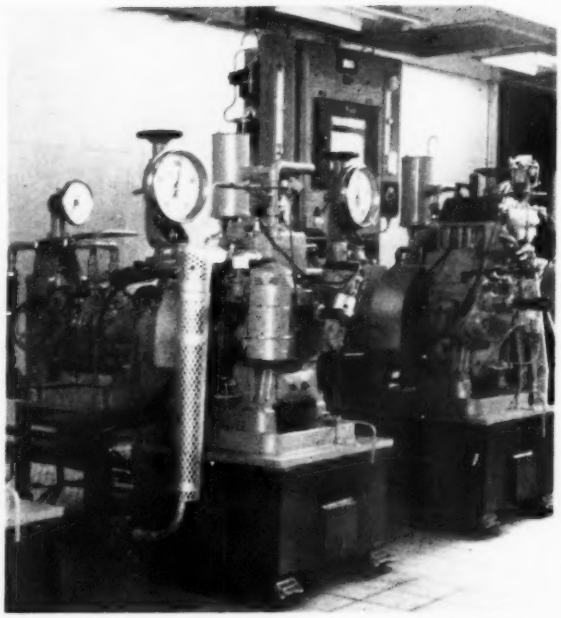
be in a car. It is sometimes possible to use the existing front or rear pick-up points of the engine but, if not, special brackets are made for the purpose. The dynamometer is carried directly on the top plate of the bed. Between the bed and the floor are placed four blocks of cork, each measuring 18 in long × 3 in wide × 2 in thick. These have proved sufficient insulation against residual vibration from the engine, and they also serve to prevent the bed from creeping.

Because of the resilient mounting of the engine, a degree of flexibility has to be incorporated between it and the dynamometer. For this purpose, a coupling of the rubber bushed trunnion type is fitted at each end of the cardan shaft; here again, the grade of rubber is suited to the engine characteristics. The first coupling is normally attached to an adaptor plate bolted to the engine flywheel. Cardan shafts are constructed as required, usually from 2 in diameter steel tube having a wall thickness of 10 s.w.g.

With all the earlier pallet arrangements, free-standing instrument and control panels were used; they are still employed in the third and fourth testing bays of the new building, because the work there sets a premium on flexibility of programming and ease of engine changing. It was logical, however, to combine the semi-permanent pallet installations of the second bay with a non-mobile layout of the instruments and controls. The panels are therefore mounted along the cross walls, behind each row of six beds, but they are far enough out for an access passage to be incorporated behind them; this passage obviates the need of removing a panel from the front to investigate a fault.

On each individual panel is a pipette for the volumetric measurement of fuel consumption; however, because diesel fuels have a greater specific gravity range than petrols, their consumption is normally measured by a mobile weighing dispenser. Three temperature recorders are installed on the panels for each bank of engines. One is a high-temperature unit, for recording all the exhaust gas temperatures, and the others are of the low-temperature type, for the oil and coolant. The temperatures of these last two items are controlled by pneumatic by-pass valves situated on the pallet, and can be pre-set on the panel.

The pallets used in the end bay for the Petter engines do not carry the dynamometer, so their top plates measure no more than 1 ft 9 in × 2 ft. They are mounted in pairs, with a free-standing panel between those of each pair. Each pallet has four rubber mountings, of the metal protected



*A closer view of two of the Petters engines. The farther of them has been modified for special purposes by the fitting of a non-standard cylinder block and an overhead valve cylinder head made from that of a car engine; the valves are actuated by fabricated push rods*

type, by which it is carried on two mild steel strips; the strips are attached to the floor by a single bolt, the purpose of which is to restrain the pallet from moving about owing to vibration. The water brakes driven by these engines are separately installed on fabricated trestles bolted to the floor. It is of interest that, because of the different routines involved, the similar pallets used in the fuels testing laboratory have their dynamometers cantilever-mounted on the pallet.

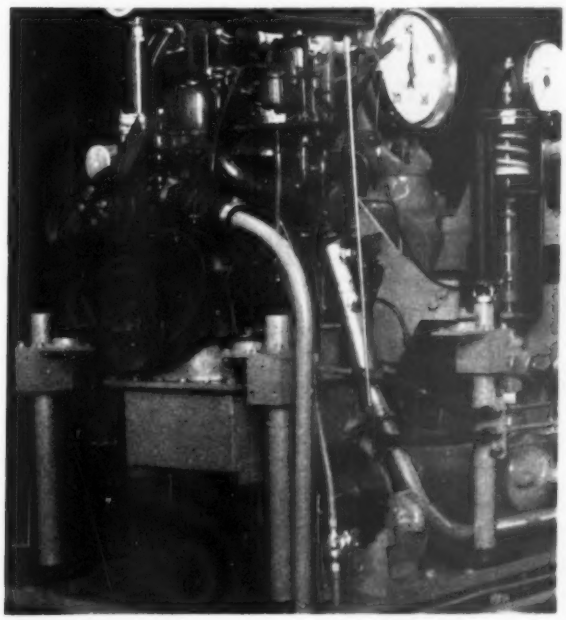
Certain tests, such as those for cold sludging, involve cyclic variations of engine speed and load. Where the programme is simple, such variations are effected by three remotely controlled solenoids that actuate the throttle linkage. For more complex programmes, a simple and versatile device is used. This consists of a resin-bonded

fabric disc driven at the required cyclic speed—usually 1 r.p.m.—by a small motor and reduction gear. Bearing on the profiled periphery of the disc is a roller follower connected to the throttle linkage. By fitting a disc of the appropriate profile, any requisite sequence of throttle openings can be given; the length of dwell of each step of the profile governs the time for which the particular setting is held. The follower is, of course, lightly spring loaded on to the disc, to ensure continuous contact.

**Services**

It has already been mentioned that all cooling water is softened before being fed to the engines; the softeners are of the familiar base-exchange type. All the cooling water for normal tests is recirculated through an evaporative cooler, which has a capacity of 500 gal/min. For the accelerated sludging tests, however, the water is required to be at a lower temperature: it is therefore taken straight from the mains, after passing through the appropriate softener, and is returned to the cooler sump to make good the evaporative losses.

The water, air and electricity services are all distributed



*In this illustration of a B.M.C. engine on a pallet bed can be seen the later type of mounting block which facilitates installation. In the foreground is a cam-disc which, revolved by a slow-speed motor, actuates the throttle to give cyclic variations of the engine load*

through a plenum tunnel, which lies beneath the covered way along the side of the building. This tunnel has a height of 6 ft and its width is ample to provide uncramped access for inspection and maintenance. Transverse service trenches, having a section of 3×3 ft, run from the tunnel into each bay. From these trenches, smaller longitudinal trenches run between the beds. Access to the trenches is by the usual removable metal flooring sections.

In the trenches, in addition to the services, is the exhaust ducting; each transverse exhaust duct leaves the building on the side remote from the plenum tunnel. These ducts feed into a single longitudinal gallery, from which they are sucked by extractor fans into the stack at the far end of the building. There is an additional extractor fan at the end of each transverse service trench remote from the plenum. The purpose of these fans is to remove any petrol or other fumes that might be unpleasant for or dangerous to the operators. A control interlock system prevents any engine from being started unless both sets of fans are running.

In respect of the exhaust system, it is of interest that, on most engines, water is sprayed into the tract immediately downstream of the manifold or outlet port. The evaporation of the water cools the gas considerably, the rate of spray being sufficient to bring the gas temperature down to about 100 deg C. Consequently, low-temperature fans and mild steel trunking can be used; in addition, engine installation is facilitated, since rubber conduit can be used to connect the engine exhaust system to the trench ducting.

To minimize fire or other hazards, the fuel lines are isolated from the other services until they reach the transverse service trenches. There are no fewer than 16 standard fuels in normal use, and they are stored in bulk in 4,000 gal tanks, installed underground beyond the far end of the building. From these tanks, the fuels are pumped up to 100 gal day-tanks carried on the roof of the building that houses the pumps, their controls and the contents gauges for the tanks.

The fuels are fed by gravity from the day-tanks, along pipes buried in a sand-filled trench, to the distribution panel, the position of which can be seen on the accompanying plan. In the room housing the panel, each pipeline has its own filter and shut-off cock, but all the cocks are connected together in such a way that, in the event of an emergency, a complete shut-off can be effected immediately. The panel consists of two sets of horizontal pipes, one of which is coupled to the supply pipes and the other to the delivery pipes for the various beds, in each case by semi-permanent connections and rigid pipes. Any one of the fuels can be connected to any bed by bridging the free unions on the appropriate input and delivery pipes with a flexible hose.

A second sand-filled trench conveys the delivery pipes

*The sixteen 4,000 gal fuel supply tanks are installed underground. From them, the fuel is pumped up to the 100 gal day tanks seen in this illustration; the feed to the distribution panel and the beds is by gravity*

along the outside of the covered way. The pipes for a particular service trench cross the plenum tunnel immediately below its ceiling, in a sealed conduit. If there is any risk of contamination of one fuel by that previously delivered to a bed, the pipeline from the panel can be flushed, or blown out with compressed air.

**Ventilation**

The ventilation of the engine test bays is worthy of comment, in that it comprises two elements. Of these, the first consists of the normal 10 air changes an hour in the bay as a whole, the air being heated in cold weather. Superimposed on this is a secondary circulation in the control and operating regions. The rate of this circulation is based on the assumption that 60 per cent of the engines are running all the time on 60 per cent of full load. It is further assumed that 15 per cent of the heat energy of the fuel is emitted as radiant and convected heat; this proportion must not raise the air temperature more than 10 deg F above ambient.

Air for the secondary system enters through diffusers suspended from the ceiling of the bay. By means of vents, some of the air is directed at the walls, in order to prevent the build up of temperature owing to heat radiated to them. Above each engine is an air collector hood from which the heated air enters an extractor duct and is discharged above the roof. Each duct embodies a thermostatically controlled damper, the purpose of which is to cause some recirculation of the warmed air in cold weather. The hoods over the larger engines are of divided construction, and the halves can be hinged up and fastened in the raised position in order to improve the accessibility of the installation.

*Most of the deep beds are mounted on coil springs. Illustrated here is the mounting, in pairs, of four of the eight springs in one bed of this type*

## Automatic Warehouse System

A NEW company, Solartron-John Brown Automation Ltd., has been formed for the manufacture and installation of the American Gumpertz automatic warehouse system. This company, which is jointly owned by Solartron Ltd., well known in the electronics field, and the world-famous engineering firm of John Brown Ltd., has the world exploitation rights, excluding America. The Gumpertz system, which is already in successful use in the U.S.A., combines electronic, electrical and mechanical elements, and would appear to have possibilities for applications such as a large manufacturer's spare parts service.

Briefly, the system comprises a longitudinal conveyor system fed by a series of transverse conveyors, which in turn are supplied from inclined shelves on which the stock is carried. Each shelf contains only one type of item and has at its lower end a barrier, which is actuated electromechanically to release one or more items on to the conveyor, according to the nature of the order.

The selection of the items required in any particular order is effected electronically: a direct-reading tape or punched-card may be employed to convey the order to the electronic equipment. It is stated in this connection that the Gumpertz system will work in conjunction with any known system of office mechanization. Since the computer, which actuates the barriers, works sequentially, starting with the items furthest from the delivery point, all the articles arrive there in a group. A second order is not accepted until the first is completed, and the average time for completion of an order with 100 or more constituents is about 15 sec from the placing of the order.

Although the layout is compact, stocking-up presents no difficulties: it can be effected either by trucks, which can readily pass along the gangways between the stacks of shelves, or from overhead hoppers. Warning is automatically given should a heavy run on an item bring the stock below a certain level. Any shortages are signalled for amendment of the advice note.

The warehouse system is tailored to the requirements of the individual firm. According to the company, it may be an economic proposition at an order level of 500 per day, but 1,000 per day is usually regarded as the lower limit. While the savings effected by use of the system will naturally vary with the order density, they could be expected to cover the capital outlay in about four years. Further details are obtainable from Solartron-John Brown Automation Ltd., 20 Eastbourne Terrace, London, W.2.

## Protection of Aluminium

ALUMINIUM and any of its alloys can be protected against climatic corrosion by a process known as Alchromate, recently introduced by P.M.D. Chemicals Ltd., Hearsall Lane, Coventry. In comparison with anodizing, the Alchromate process is claimed to have several advantages. The protective film is ductile and electrically conductive, while the maximum processing time is five minutes, a quarter, or less, of that required for anodic treatment. No electric current is used in the process, which is simple and economical in use.

The solution is contained in a tank of stainless steel, or mild steel coated with p.v.c., polythene or Neoprene; mild steel is used for the rinsing tank. An operating temperature of 90 ±10 deg F is necessary for the solution. Most components need only degreasing or a mild alkali cleaning before treatment. The solution is supplied in concentrated form, which is diluted with tap water in the ratio of one part to nine of water. For the treatment of very large areas, the process can be modified slightly to permit application of the solution by swab or brush.

According to the manufacturers, paint adhesion to the treated parts is excellent, and the Alchromate film inhibits corrosion in the event of damage to the painted surface. If adhesives are used to unite aluminium components, the coating provides a sound key. Also, there is no deterioration of treated items in storage, and the process is not harmful to steel or brass inserts. Finally, damaged anodic films can be repaired by swabbing with the Alchromate solution.

# Recent German Publications

*Brief Reviews of Current Technical Books*

**Messungen der dynamischen Radlasten und Entwicklung eines Prüfhindernisses zur Feststellung strassenschonender Fahrzeugbauweisen. (Measurement of Dynamic Wheel Loads and Development of a Test Obstacle to Determine which Vehicle Designs do Least Damage to the Road.) Deutsche Kraftfahrtforschung und Strassenverkehrstechnik, No. 127.**

*In German, by P. Koessler, Prof. Dr. Ing, M. Mitschke, Dr. Ing, H. G. Beermann, Dr. Ing. and H. V. Bruchhausen, Dipl.-Ing.* Düsseldorf: VDI-Verlag G.m.b.H, 1959. $11\frac{1}{4} \times 8\frac{1}{4}$. 42 pp. Price D.M. 26.60.

Increasing costs of road maintenance make it more than ever necessary to establish the relative damage likely to be imposed by various vehicle types and *inter alia* what are the design features least likely to inflict damage on the road surface. The problem is a common one and applies to rail as well as road vehicles: for example, British Railways, in the absence of a better criterion, aim at $P/D < 5$, where $P$ is the axle load in tons and $D$ the wheel diameter in ft. The object of this limit is to safeguard the rails from excessive contact stresses, but since this cannot take into account the effect of suspension characteristics, speed, inertias or the statistical aspects of operation, its effectiveness is at least problematic.

This report fills a gap in this sphere of engineering endeavour since, to begin with, an attempt is made to correlate the foreseeable magnitudes of dynamic load with important design parameters such as masses, spring and tyre stiffness data, and other factors, including road obstacles. Next, road tests are considered with regard to calibration and test procedure and the evaluation of the test results. The latter are evaluated on a statistical basis, with reference to vehicle characteristics, road conditions and speed. Since vehicle development logically entails clarification of the finer points of design with the aid of a rig, the results of these tests were evaluated with a view to subsequent work with an obstacle rig. A suitable rig was evolved and used for vehicle testing, and some of the results obtained have been suitably evaluated and considered in the second part of the report. This report forms a valuable contribution to the future evolution of vehicle design with particular reference to the interaction between vehicle and road, and possibly also, in the distant future, between vehicle and taxation pattern.

**Untersuchungen über die dynamischen Kräfte zwischen Rad und Fahrbahn und ihre Auswirkung auf die Beanspruchung der Strasse. (Investigation of the Dynamic Forces Between Wheel and Road and their Effect on the Stresses Imposed on the Road.) Deutsche Kraftfahrtforschung und Strassenverkehrstechnik, No. 130.**

*In German, by O. Svenson, Dr. Ing.* Düsseldorf: VDI-Verlag G.m.b.H, 1959. $11\frac{1}{4} \times 8\frac{1}{4}$. 15 pp. Price D.M. 13.90.

Work in this report was stimulated by consideration in Germany as to whether the maximum permissible axle load of heavy commercial vehicles should be limited to 8 or to 10 tonnes, and to what extent vehicle design parameters are likely to influence the amount of damage inflicted upon the road. Because of the obvious importance and complexity of the problem, the Federal Ministry of Transport asked a number of Technical High Schools and research establishments to consider the matter, and this report is on the results of the work carried out at the Laboratory for Operational Strength, at Darmstadt-Eberstadt.

The complexity of the problem in terms of interrelation between first cost, weight, complexity and maintenance expenses, and the interaction between vehicle and road, are briefly considered with particular reference to the fact that vehicle designers lack data relating to the vehicle characteristics affecting road deterioration, particularly relative to traffic intensity. In considering vertical forces, the author correlates available information indicating that tyre stiffness is of predominant importance so far as dynamic wheel loads are concerned. A simple relationship between tyre stiffness, static load and the dynamic augment has been developed, and calculations on this basis, according to the author, give the designer results to within $\pm 20$ per cent accuracy.

Effects of dampers and axle mass on the dynamic loads are briefly considered, and it is concluded that suitable damper matching might be of appreciable assistance in reducing the dynamic wheel loads. Next, the author considers the lateral forces imposed on the road surface and also the fatigue resistance of roads, and then presents a summary of the results of road tests carried out on lorries, trailers and buses. He concludes that the dynamic load augment could be reduced at the best by about 30 per cent, thus reducing by only 10 to 20 per cent the total load imposed on the road surface. While, therefore, it would not appear that much can be expected so far as vehicle design is concerned, the question regarding the permissible maximum axle load must be considered with reference to the likely intensity of traffic to be faced in the future.

**Das Betriebsverhalten des schnellaufenden Zweitakt-Ottomotors mit Einspritzung und seine Entwicklungsmöglichkeiten. (The Operating Characteristics of the High-Speed Two-Stroke Otto Engine with Petrol Injection, and the Possibility of its Development.) Deutsche Kraftfahrtforschung und Strassenverkehrstechnik, No. 125.**

*In German, by K. Groth, Priv. Doz. Dr. Ing.* Düsseldorf: VDI-Verlag G.m.b.H, 1959. $11\frac{1}{4} \times 8\frac{1}{4}$. 63 pp. Price D.M. 28.20.

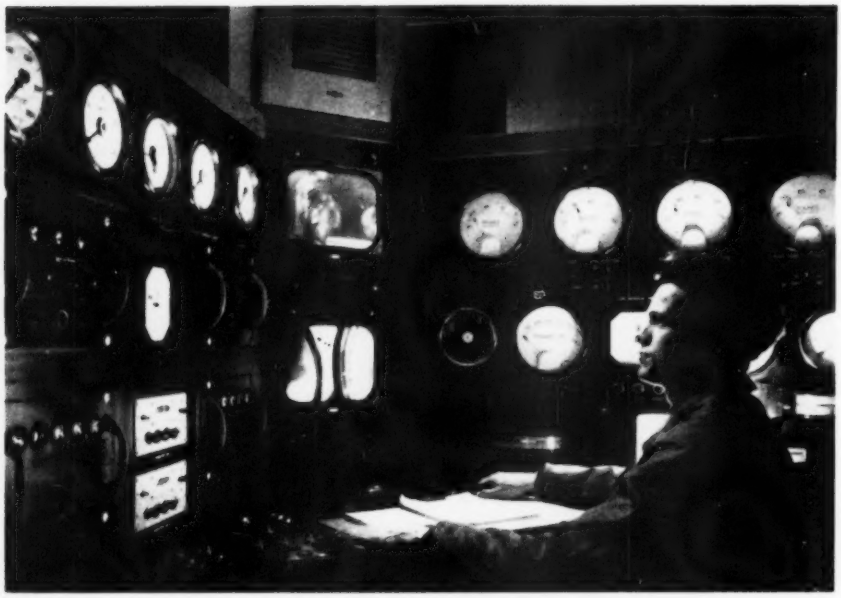
Whilst petrol injection has been accepted for a few makes of engine, the general principles understood, and the finer points appreciated so far as four-stroke units are concerned, it has not so far been so thoroughly studied in connection with two-stroke engines. This report describes an appreciable volume of research by the author to obtain a better insight regarding the part-load characteristics of crankcase scavenge engines, the fuel-air mixing process, the influence of compression, and other factors such as octane numbers and scavenging, *vis-à-vis* the standard carburettor engine. Particular attention is given to the reduction of fuel and lubricating oil consumption, the process of fuel-air mixing, the effect of the position of the injection nozzle relative to the sparking plug, and the finer points such as timing and air velocity. The results of rig tests on a single-cylinder and a two-cylinder engine are reported and considered in great detail. In addition to reporting on his own work, the author comments on the results obtained by other investigators in this field; a bibliography is included, and it gives some 160 references. This is a thorough and valuable report, which does much to clarify the problems associated with the function of the two-stroke petrol-injection engine.

**Versuche zur Entwicklung bleifester Katalysatoren für die Katalytische Nachverbrennung der Abgase von Ottomotoren. (Development of Lead-Resistant Catalysts for Catalytic Afterburning of Exhaust Gases of Otto Engines.) Deutsche Kraftfahrtforschung und Strassenverkehrstechnik, No. 129.**

*In German, by R. Essig, Anneliese Kaiser and A. Reuter, Dr.* Düsseldorf: VDI-Verlag G.m.b.H, 1959. $11\frac{1}{4} \times 8\frac{1}{4}$. 13 pp. Price D.M. 11.80.

The need for reducing the harmful and annoying effects of vehicle exhaust gases has led the Federal Ministry of Transport to request the Battelle Institute, Frankfurt, to investigate the possibility of evolving a catalytic exhaust gas after-burner. A result is the report under review, in which is considered the nature of the task, the available published work, and describes the experimental equipment used to ascertain the effectiveness of catalysts. The results of the tests are discussed in some detail. It is concluded that the use of catalytic after-burners offers possibilities, as already indicated by the development of experimental units; however, so far, these units have been too heavy and bulky, so extensive research and development work will be required before a satisfactory solution is reached. Avenues of approach which might be pursued to this end are suggested. Thus, whilst it can be considered only as an interim step, the report is helpful in showing the present state of our knowledge, elucidating a complex problem, and proposing possible lines of attack. Undoubtedly it will stimulate further work in this field.

# DUNLOP HIGH-SPEED TYRE TEST PLANT



*Between the two control panels can be seen the screens of the closed-circuit television system; above them is the loud speaker by which the noise of a tyre under test is made audible to the operators. The panels of the two Dekatron counting units are visible on the extreme left side*

***Underground Machine Room. Remote Control and Closed-Circuit Television are among the Features of a New Installation for Speeds of 500 m.p.h. and More***

IT is now more than 30 years since the Dunlop Rubber Co. Ltd. installed its original high-speed tyre testing plant. During the subsequent period, this plant was developed until it was capable of testing tyres at speeds of up to 420 m.p.h. However, this speed represented the limit of the machine's capabilities, so when the necessity arose of running the tyres of Donald Campbell's world land speed record challenger at up to 500 m.p.h., it was clear that new equipment would be necessary. Work was at once put in hand, and the latest test unit was, in fact, completed last September, though details have only recently been released. While primarily intended for tyre tests at ultra-high speeds, up to 550 m.p.h. under load, the plant will also be used to supplement the existing equipment for normal high-speed testing, since it can operate satisfactorily over the complete speed range down to 60 m.p.h.

A brief outline of the particular problems encountered in the design of very high-speed tyres may at this point be relevant. In the first place, the centrifugal forces involved, which vary with the weight and the square of the angular velocity, are enormous, and the tyre must be physically strong enough to resist them. It is on this account also that the tread portion of the tyre must be of the minimum thickness consistent with adequate resistance to wear and damage during the short run involved. Moreover, the tyre must be able to transmit the very high torque necessary, at elevated speeds, to overcome the vehicle's resistance to motion; the bulk of this resistance is air drag which, of course, varies as the square of the speed. If the tyre will withstand the power throughput at its maximum speed, it will generally be adequate for the necessary acceleration and braking.

Heat is probably rubber's worst enemy, and excessive internal temperatures within the rubber can destroy a tyre very quickly. It follows that the power consumption in the tyre must be kept to a minimum. In this connection, it is essential that there should be no standing wave or "ripple" when the tyre is running at any speed up to the maximum for which it is designed. This standing wave, an oscillation phase through which each part of the tyre structure passes, occurs when the so-called critical speed is reached. The critical speed depends on the design and construction of the tyre and its inflation pressure. When the standing wave is occurring, a large amount of energy is absorbed by the tyre, with consequent high temperatures and severe strains of the casing.

**Test plant layout**

The actual test machine follows the familiar design, in which the tyre is run in contact, at a predetermined load, with a revolving drum. This method is preferred by the Dunlop technicians to the alternative of running two identical tyres together: time is saved because only one tyre of a particular type has to be built, though allowance has to be made for the fact that the contact patch is concave and not flat, which in fact increases the severity of the test.

Because of the very high speeds and the energy to be dissipated in the event of a tyre failure, it was clearly essential at the design stage to ensure the safety of test personnel. On this account, the machine is installed in an underground room; the instrumentation and controls are remotely housed, in a single-storey building next to the dynamometer room.

Before the machine can be started, the door of the dynamometer room must be locked, and the key used to operate the master switch on the control panel. In the

event of a member of the test staff being inadvertently locked in the room, an emergency stop button is fitted there in an accessible position. In addition, any possibility of damage to the equipment as a result of component failure or incorrect usage is obviated by the incorporation of an electrical multiple interlock system, which has no fewer than 130 elements. Unless all these are correctly set, the machine cannot be run.

For the essential visual observation of the behaviour of the tyre during testing, a Pye closed-circuit television system is employed. It has two cameras, mounted side-by-side on an optical bench in a cubicle adjacent to the dynamometer room. The wall between the cubicle and the room embodies a longitudinal slot through which the cameras are aimed. One of the cameras is permanently focused on the region of contact between tyre and drum, whereas the second is used to view any other part of the equipment within its field of vision; each has two lenses, normal and close-up, the changeover being effected by remote control. The two television screens are installed, one above the other, between the two parts of the instrument panel in the control room.

A pictorial record of any phase of a test can be obtained by means of a still camera, mounted next to the television cameras and also operated by remote control. In the dynamometer room, near the drum and tyre, is a directional microphone, whereby the tyre-drum noise is transmitted through an amplifier to a loud speaker fitted above the television screens. It is valuable to be able to listen to, as well as view, the tests because incipient failure of a tyre and the onset of the standing wave are both indicated by a change of note. Air conditioning equipment forms part of the test plant, and the ambient temperature within the dynamometer room is controlled to simulate the actual operating conditions of the tyre.

**Dynamometer equipment**

Heenan and Froude Ltd. have been responsible for the manufacture and installation of the dynamometer equipment. There are separate driving systems for the drum and the tyre, each having Ward-Leonard electrical control. To permit the tyre to be brought into or out of contact with the drum, its wheel and the motor and drive are mounted on a carriage that can be moved laterally by a hydraulic ram. Since this unit weighs about 4 tons, and friction in the system could result in inaccuracies in measuring the load between tyre and drum, the carriage floats clear of its bed on air bearings.

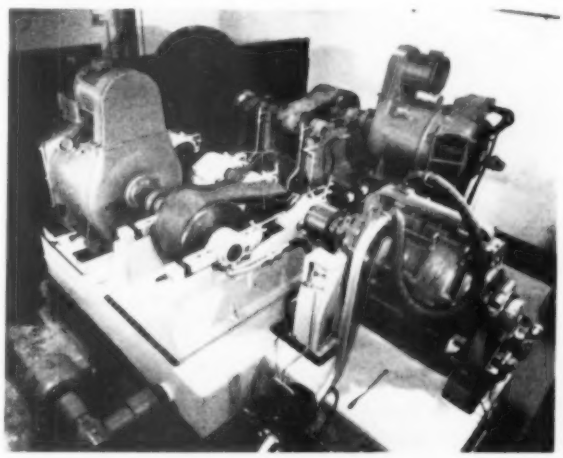
The drum is a steel forging weighing 30 cwt; it has a diameter of 67·2 in, a rim width of 7 in, and a moment of inertia of 338 slugs-ft$^2$. Its 3½ in diameter shaft is carried in plain bearings, which are pressure lubricated, the oil serving also as a coolant. The shaft is driven by a 450 h.p. induction motor and a transmission assembly comprising a torque meter and a step-up flat belt drive having a ratio of 1·9 : 1; the maximum speed of the motor is 1,800 r.p.m, and 1,450 r.p.m. gives a linear speed of 550 m.p.h. at the rim of the drum.

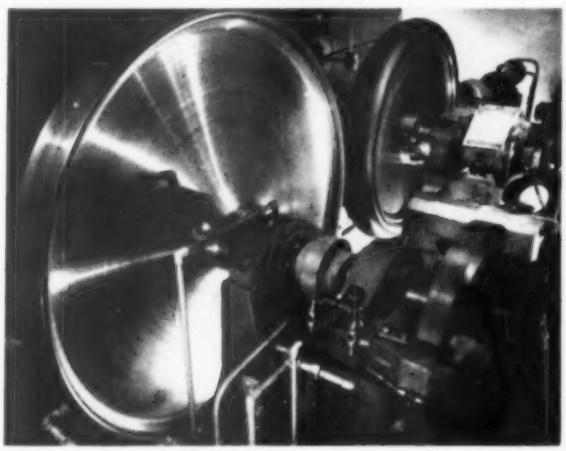
A similar driving method is employed for the tyre wheel, which will be described later, except that the motor output is 250 h.p. and a universally jointed shaft is interposed in the transmission line, immediately adjacent to the wheel, to avoid any possibility of trouble through malalignment. The maximum speed of this second motor is also 1,800 r.p.m. and the step-up ratio of the belt drive is 2·94 : 1. It is therefore possible for the 7·0—41 in tyres for Donald Campbell's vehicle to be run at peripheral speeds of up to 650 m.p.h. when centrifugal effects only are being investigated on the machine.

For the peripheral speed of the tyre to be known exactly, the amount of fling—or radial extension under centrifugal loading—must be accurately measured. This is done by using the close-up lens on the first television camera, and imposing a graticule on the image on the screen. In this way, the fling can be measured to within 0·001 in. The deflection of the tyre under load can be measured in the same way, though there is an alternative method. This latter involves setting the camera so that one vertical of the graticule is tangential to the wheel rim before the load is applied. When the wheel and tyre assembly is loaded, the camera is traversed until that vertical is again tangential to the rim. The optical bench mounting of the camera enables the distance between the two positions of the camera to be accurately determined.

The direction of rotation of the tyre and drum is such that their peripheries are travelling upward through the contact area. This direction was chosen because the forces applied when the tyre is under load then oppose the weight of the carriage, thereby helping to reduce friction. Also, any standing wave formation is clearly visible.

Mention has already been made that hydraulic pressure is used to press the tyre against the drum. The hydraulic ram has been specially designed to give the smoothest possible action, and very fine control is provided. A load





*Above: General view of the two motors and their drives; the nearer unit is for driving the tyre wheel, and its carriage floats on air bearings. Below: The steel drum has a diameter of 67·2 in and weighs 30 cwt. Its shaft and that of the tyre wheel are both fitted with disc brakes*

cell is interposed between the ram and the carriage, to enable the applied load to be measured, and the horizontal and vertical reactions at the wheel spindle bearings are recorded. The maximum loading that can be applied by the ram is 26 cwt.

Torque measurement is effected by embodying a torsion shaft into each of the two drive systems. At each end of the shaft is a toothed wheel, which is scanned by a photo-electric detector. Twisting of the shaft produces a phase difference between the signals from the two ends of the shaft, and this phase difference is proportional to the torque involved. The signals obtained from the detectors are also employed, in conjunction with two electronic counting units of the familiar Dekatron type, to provide very precise measurement of the shaft speeds.

The amount of energy that has to be dissipated to stop the machines is clearly enormous, and excessive delays in bringing them to rest must be avoided if the temperature measurements are to be sufficiently accurate. For this reason, and for emergency purposes, both the drum and the wheel are fitted with disc brakes in addition to the regenerative electrical braking. The brake on the wheel shaft is a Dunlop car type unit of $11\frac{1}{2}$ in diameter, and it is standard except that it has two caliper units, disposed mutually at 180 deg, instead of one. Because of the higher kinetic energy of the drum, its shaft carries a larger industrial disc brake: the diameter and thickness of the disc are respectively 22 in and $2\frac{1}{8}$ in, and the two calipers are mounted on the structure supporting the shaft. Using both braking systems, the drum can be brought to rest from 500 m.p.h. in 50 seconds; the corresponding minimum time for the tyre wheel is under 30 seconds.

Should a tyre fail under load, the extra traverse of the carriage trips a limit switch; this immediately causes the wheel and tyre assembly to be automatically withdrawn from the drum and the brakes to be applied. In the control room is an emergency switch that initiates the same sequence of events. Should the plant be stopped by the automatic operation of the interlock system, identification of the source of trouble is assisted by illuminated indicators, also installed in the control room.

### Testing sequence

Four types of test are carried out, the first being the free fling test, for the study of centrifugal effects at various speeds, without other loading. The torsion shaft in the drive to the wheel can be used for the measurement of the power required to overcome windage. This power requirement must, of course, be added to that necessary for overcoming the rolling and air resistances of the complete vehicle.

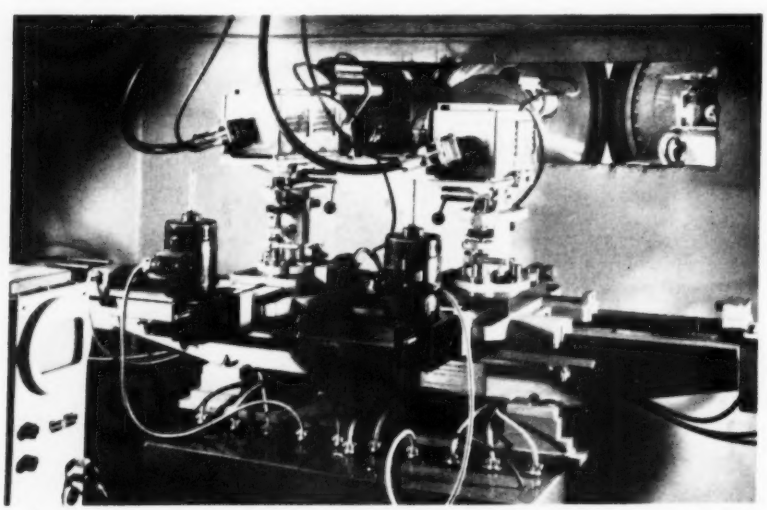
In very high-speed tests, the drum and the tyre are separately run up to the same peripheral speed before contact is made. Failure to match the speeds exactly would result in overstressing of the tyre, with the consequent possibility of early failure. The motors are accelerated to the approximate required speed, as measured by means of normal tachometers, but for the final matching, which may take as long as 15 minutes, the Dekatron counters are used.

When the peripheral speeds have been equalized within $\pm 5$ r.p.m, the tyre is moved towards the drum, and its drive is automatically disengaged just before contact is made: during the actual run, the tyre is driven only by the drum. After application of the desired radial load, the run is continued at a steady drum speed for a predetermined period. In the case of world speed record tyres, this period is one minute. The tyre temperature is measured immediately after the run, using a sensitive thermocouple probe carefully inserted in the tread; then the dimensions of the tyre are accurately measured, to determine the amount of permanent strain, and the tread surface is minutely examined for signs of damage.

A similar technique can be employed for normal high-speed tests, for which the maximum speed is at present about 200 m.p.h. Alternatively, the wheel drive can be disconnected and the tyre brought up to speed by light contact with the already revolving drum. When the speeds of the two are steady, the required load is applied. The fourth type of test is known as the controlled braking test, in which the tyre is first put through the normal test sequence. At the end of the run, the drum drive is switched off and regenerative braking is applied to the tyre wheel drive, to bring both the tyre and the drum to rest.

### C.N.7 tyres and wheels

It is appropriate to complete this article with a brief description of the tyres evolved for Donald Campbell's C.N.7 vehicle — the initial letters signify Campbell and Norris Bros. Ltd, the consulting engineers responsible for the design. Tubes are employed in these tyres. According to the Dunlop technicians, tubeless tyres would have been equally practicable for the purpose but, because the company's previous work in this field had been on tubed tyres, it was felt that development time would be saved by



*The two Pye television cameras are mounted on an optical bench in a cubicle adjacent to the dynamometer room. Both have normal and close-up lenses, with remote control of the changeover, and they view the test machine through a slot in the dividing wall*

*Exterior view of the new test plant. In the foreground are the ventilation shafts of the underground machine room; all the instruments and controls are housed in the adjoining single-storey building. In addition, this building contains the power supply room, in which are installed the switch gear and the rectifier equipment*

the best utilization of that knowledge already acquired.

The tyres have an overall diameter of 52 in and a section width of 8 in; they are mounted on 41 in diameter rims, the width of which is relatively large compared with that of the tyre: it is noteworthy that, in comparison with earlier record breaking tyres, a much more squat section is employed. The purpose of this low profile is to shorten the side walls and thus reduce the strain resulting from a given centrifugal stress. Tests have indicated that the radial fling is restricted to about $\frac{1}{4}$ in at 500 m.p.h. The load per wheel is about 1 ton, which produces a static deflection of approximately $\frac{3}{8}$ in.

For the casing, Fortisan rayon, a high-tensile low-stretch material, is used. The outer covering, which is only 0·020 in thick, is of natural rubber, as is the tube. Inflation is with nitrogen to an undisclosed pressure, above 100 lb/in$^2$. This dry gas gives a controlled increase in pressure as the tyre temperature rises, whereas if moist air from a compressor were used, the pressure rise would vary according to the amount of water vapour present. In this connection, the tests have shown that a temperature of about 60 deg C is reached in the tyre by the end of a high-speed run. The weight of a cover is given as approximately 50 lb, the corresponding figure for a standard 6.50-15 in car tyre being 20 lb.

For lateral rigidity, the discs of the high-tensile steel wheels have a considerable dish. Each disc is integral with the inboard portion of the divided rim; the detachable outboard portion of the rim is retained by a ring of bolts and nuts. This two-piece construction is necessary to enable the tyre to be fitted. A positive grip of the rim on the tyre is ensured by the use of a bead spacer. One of these wheels, which are also of Dunlop manufacture, has been used in the tyre testing. Each complete wheel and tyre assembly is balanced before testing, and unbalance equivalent to $\frac{1}{4}$ oz at the periphery must not be exceeded.

## New Sound-Deadening Material

IN VIEW of the increasing emphasis that is being placed on the sound insulation of cars and other road vehicles, a material recently introduced by Supra Chemicals and Paints Ltd., will be of interest. This company has specialized in such materials for a number of years. The new compound is of the bituminous type and is known as Dedshete, and it is claimed to be an extremely efficient suppressor of noise, whether air-borne or transmitted by panel resonance.

It is manufactured, as the name suggests, in sheet form, is self-adherent and is applied quite simply by placing the sheet on the panel, and stoving for 5 min at 300 deg F. During the stoving period, the material moulds, and adheres, to any contour. This adhesion is said to be permanent, and re-stoving, for example, can subsequently be carried out at temperatures up to 350 deg F without adverse effect. Since Dedshete adheres readily to any reasonably clean surface, even to stock-oiled sheet, prior degreasing of the metal is not necessary.

Apart from this ease of application, the material is claimed to have the important benefits of low price and minimal waste. The basic cost is relatively low, and sheets can be supplied cut to any size or shape within the limits of 42 in × 30 in. Labour costs also are small, because of the virtual absence of preparation. Adhesion is unaffected by phosphating or other pre-painting treatment, or by hot water, detergents or dilute acids or alkalis. The material can be over-painted, though the manufacturers state that slight discoloration is likely to occur with light and pastel shades. Samples of Dedshete and prices for particular applications may be obtained from Supra Chemicals and Paints Ltd., Hainge Road, Tividale, Tipton, Staffs.

## Translations of German Standards

AS WAS stated in the May 1960 issue of *Automobile Engineer*, the translation of German standards into the English language by the Deutscher Normenausschuss, Berlin W 15, Uhlandstrasse 175, is now a regular feature. During May, about twenty standards were translated, and among them are the following:

**DIN UDC 669.2/.8 Non-ferrous metals**—1701, REFINED NICKEL, *July 1958.* 1702, NICKEL ANODES, *May 1956.* 1706, ZINC, *September 1952*

**678.5/.8 Plastics**—7743, PLASTICS: *types of moulding materials, cellulose acetate butyrate (CAB) injection moulding materials, May 1959X*

**678.5/.8 : 620.1 Testing of plastics**—53388, TESTING OF PLASTICS: *determining resistance to light, July 1959.* 53445, *Sheet 1, torsion pendulum test, preliminary standard, September 1959*

**74 Drawing, technical drawing equipment**—DRAWING PRACTICE: 5, *axonometric projections, October 1948;* 6, *views, sections, special methods of representation, October 1956;* 15, *Sheet 1, lines, June 1955. Sheet 2, examples of use, June 1955.*

# THE MACHINE TOOL EXHIBITION

*Part II: A Review, Continued from the Previous Issue, of Interesting Tools and Equipment Recently Displayed at Olympia, London*

SEMI-AUTOMATIC or automatic cycling of broaching machines has long been established but present-day production requirements have accelerated the incorporation of feeding, loading and discharging equipment to give fully automatic operation. Usually such equipment must be "tailored" for a specific component or group of components and, although the basic machine and individual items of equipment are standardized, each application is studied and treated as a special. Currently, the latest designs of some of the concerns manufacturing broaching machines are almost exclusively for machines that are completely independent of hand feeding.

One such firm, Karl Klink, of Niefern (Baden), Germany, showed a fully automatic, hydraulic, twin-tool, vertical machine for broaching the internal teeth of a synchromesh ring gear. These machines, of the double-column type, can be equipped with indexing tables and automatic loading and ejection devices under electro-hydraulic control. The machine illustrated, of 20-ton capacity and 50 in stroke, cycles in 30 sec and with duplicated tooling has an output of 240 pieces/hr.

The components are fed to the machine down a gravity channel and released in pairs to a vertical, chain-type elevator that raises them to the table level. There they are delivered to a rotary indexing device that transfers them to the work station and, after the broaching cycle is completed, conveys them to the opposite side of the machine and ejects them to a delivery chute.

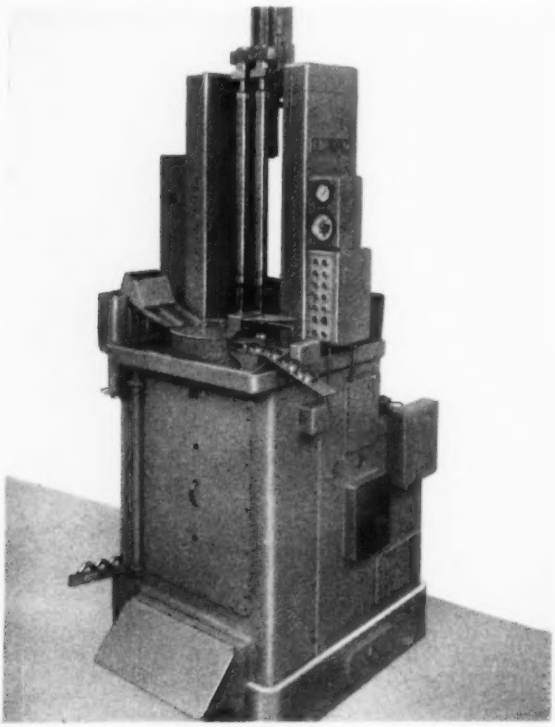
Automation is also applied to external broaching machines and combined internal and external machines for broaching bores and external surfaces in successive operations. One Karl Klink machine, of 10-ton capacity, 48 in stroke, and 22 sec cycle, is tooled for broaching screw slots. Four vibrating hoppers feed the screws down channels to the double-sided holding fixture on the sliding table. A full charge of this fixture is 15 screws, and 15 broaching tools are accommodated on the main tool slide. After broaching, the parts are automatically discharged down a chute to a collection bin. Output is approximately 2,500 pieces/hr.

Sole agents for Karl Klink machines are Alexander S. Newall Machine Tool Co. Ltd, of London, N.W.3.

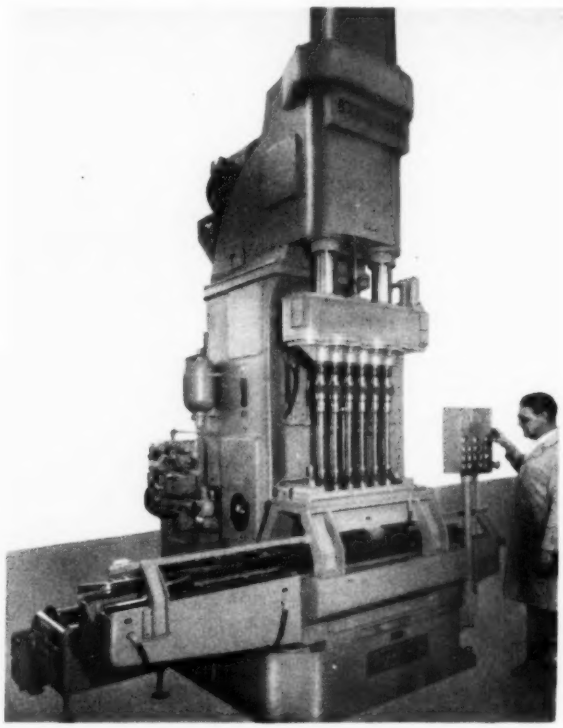
**Bore-honing machines**

Available with three, four, six, or eight spindles, the Model 320 honing machine built by the Barnes Drill Co., Rockford, Illinois, U.S.A, is designed specifically to meet the requirements of the automobile industry. The centre distance between spindles can be arranged to suit individual applications and the maker's "Plugmatic" automatic sizing system will maintain consistency in bore diameters within

*Fully automatic, twin tool, internal broaching machine by Karl Klink*



*Barnesdril six-spindle machine for honing engine cylinder bores*



0·0005 in. A motor of suitable horse-power, from 20 to 40, drives the spindles at a constant speed within the range of 100 to 500 rev/min by selection of pick-off gears. Drive is transmitted by hardened and ground helical crown and bevel wheels to two splined spindles passing through the two 5 in diameter rams, to the lower ends of which the multi-spindle auxiliary head is attached. All drive shafts run in ball bearings.

Stroking is effected hydraulically by a system independently powered by a motor of from 15 to 20 h.p. Length of stroke is adjustable by a dial control from 2 in to a maximum of 20 in and stroking speed from 10 to 80 ft/min can be regulated by a volume control on the hydraulic tank. The well-proven "Plugmatic" sizing system has for each bore a carbide-tipped, self-aligning, spring-loaded gauging member which, when size is reached and it enters the bore, trips a sizing limit switch and stops hone expansion. When all bores are sized the head is retracted, withdrawing the honing tools, and the cycle is completed. Either pneumatic or electronic methods of hone expansion can be provided; each has rapid expansion and rapid collapse movements to reduce cycle time.

Lubrication is by pump to all moving parts. An automatic safety switch prevents the spindle motor being started unless the lubrication pump is operating and oil is circulating. The weight of the multi-spindle head and the honing tools is counterbalanced by air pressure to ensure smooth reversal of the honing stroke. This counterbalance system also serves as a safety device since it will support the weight of the head when the hydraulic system is inoperative. A safety latch keeps the head from dropping should the air supply be cut when the machine is shut down. Hydraulic and electrical systems have a safety interlock that renders operation impossible until the work is securely clamped in position.

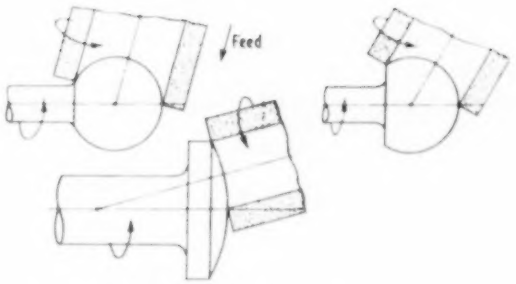
The coolant reservoir, integral with the machine base, has a capacity of about 150 gal. The maker's specially developed Kleenall combination magnetic and fabric filter is used to provide consistent clarity of the fluid. When cylinders are required to exceptionally close tolerances, refrigeration equipment is supplied to maintain a constant coolant temperature. The six-spindle machine shown by Gaston E. Marbaix Ltd, the British agents, was fitted with a Frigidaire refrigeration plant.

**Spherical grinding**

A part-spherical surface that is integral with a shaft, rod, or pin presents difficulties in production. If a formed tool or grinding wheel is used it must be first produced and subsequently maintained to an accuracy at least equal to that of the finished component. The difference in peripheral speeds at the equator and a pole of the workpiece gives unequal cutting speeds, and a true sphere can be generated only if the work diameter is precisely twice the radius of the formed tool. No tolerance can be allowed on diameter since any deviation from size will produce errors in sphericity.

In an alternative method, the wheel or tool is pivotally mounted and traversed around the workpiece in a circular path. Errors will be introduced by any inaccuracy at the pivotal bearings and also by imprecise positioning of the pivot in relation to the work axis. With either method, the work will be concentrically ridged and if a fine finish is required resort must be had to a lapping operation.

A novel principle is employed in the grinding machine introduced by High Precision Equipment Ltd, of Bletchley, Buckinghamshire. As shown in the line diagrams, the workpiece is rotated and a hollow cylindrical grinding wheel rotating in the opposite direction is fed in at an appropriate angle. The bore of the wheel is precisely of a diameter




*Set-up for grinding part-spherical surfaces on H.P.E. machines*

equal to the chordal distance from the pole of the work to the extremity of the spherical surface. Wheel wear at the edge of the bore does not affect component size as the diameter of the bore is the controlling factor. Spherical accuracy to within 0·0001 in on radius can be attained.

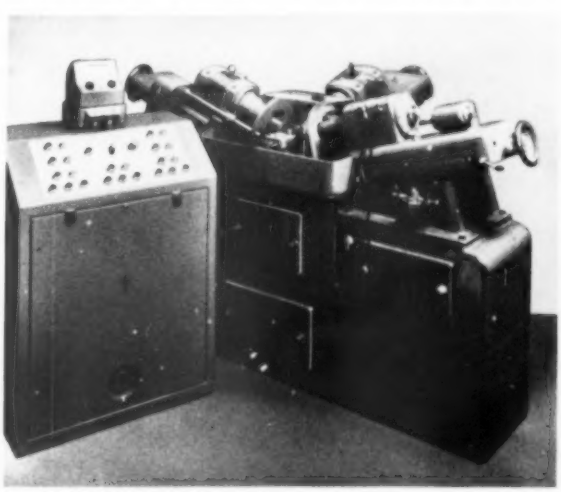
For use on a specific component it is only necessary to size the bore of grinding wheel once to ±0·001 in. The slide of the boring attachment, which carries a diamond tool, is fitted with a micrometer adjustment. As the wheel wears it is automatically trimmed merely by traversing the diamond across the face of the wheel. Control is effected electronically by means of a comparator probe which runs in contact with the work while grinding is in progress. This not only gives a visual indication of size but controls the slide movements and, in the case of multi-spindle machines, the sequence of operations.

Single-spindle machines are suitable for the production of components where a finish of 15-25 micro-inch and a tolerance of 0·001 in are acceptable, when an output of 100 pieces/hr can be maintained. Two-spindle machines are intended for work where a finish better than 15 micro-inch is required. The two spindles operate consecutively; the second spindle carrying a fine-grit wheel to attain the surface finish. For precision work, accurate to 0·0005 in on diameter and finish better than 4 micro-inch, three-spindle machines are available. These machines have an output of 20 pieces/hr.

In quantity production, the method offers several important advantages.

1. The surface is always spherical, irrespective of wheel wear or oversize variation of component diameter

*H.P.E. spherical grinding machine with electronic size control*



*Hegenscheidt crankpin fillet-rolling machine for four-throw shafts*

2. Positioning of the spherical surface relative to other parts of the component can be held to close tolerances
3. Grinding can be carried out over the pole of the sphere.

In addition to general-purpose and precision universal machines, which can also grind internal surfaces not exceeding a hemisphere, standard units are also produced for building into special-purpose machines or production lines. These can be ganged as necessary to meet production requirements. The latest machine envisaged will hopper-feed steering ball pins with the ball as forged or in rough-turned condition, rough grind, induction harden, quench, finish grind, and unload at a rate of 150 pieces/hr.

**Crankshaft fillet-rolling machines**

The proportions and the finish of the fillets of journals and pins exercise an important influence on the strength of a crankshaft. In recent years intensive studies have been made of the improvement in fatigue strength to be gained by cold-working the fillets by a deep rolling process. Machines are now available for rolling the fillets of the pins or of both the journals and pins. They are designed as production machines but can also be used to good effect by firms operating an engine replacement service. Practice differs from firm to firm, but commonly a worn crankshaft can be reground to two standardized reduced diameters before it is required to be scrapped. If the fillets are worked by rolling it is quite safe to reduce one step further.

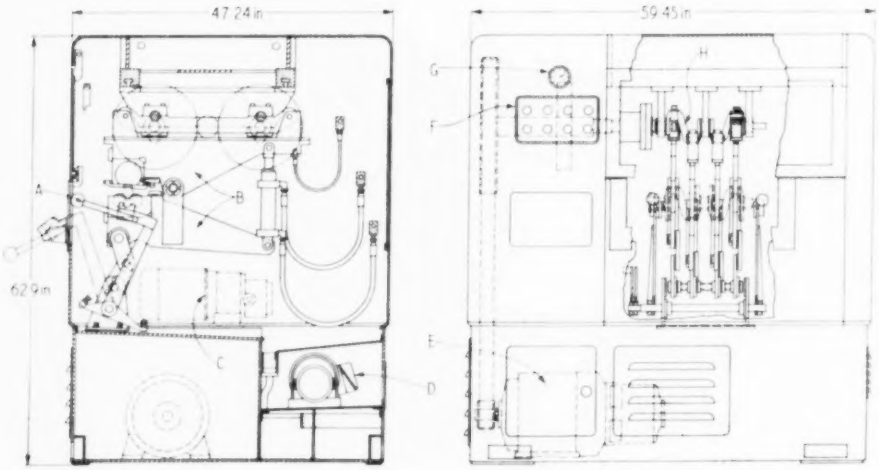
A machine designed by the German firm Wilhelm Hegenscheidt KG, Erkelenz, Rhineland, for a European car manufacturer, was exhibited. This has four rolling units and is intended for operation only on the pins of a four-throw crankshaft. As may be seen in the line drawing, each rolling unit comprises a pair of pivotally coupled levers controlled by a hydraulic cylinder. The upper lever takes its bearing and support on the pins of a pair of production crankshafts running parallel in journal bearings suspended from a framing in the head of the machine. Suspension brackets are adjustable along T-slotted guideways in order to accommodate, within the machine's overall capacity, differently dimensioned crankshafts. The two crankshafts, geared together and belt-driven from a motor in the base of the machine, thus reproduce the motion of the crankpins at the operating position of the rolling unit. The levers carry small-diameter, hardened rollers set at an angle of 45 deg for the fillet rolling operation.

Manual loading and unloading is employed. The component is placed in a pivotally mounted cradle by which it is transferred to the jaws of the rolling units. Thereafter, control is by push-button, initiating an automatic cycle that closes the rollers on the component, starts the driving motor, applies a pre-set pressure to the rollers for a selected number of revolutions, eases off the pressure, stops the driving motor, and finally opens the jaws of the rolling unit.

Elgar Machine Tool Co. Ltd. are sole agents for the Hegenscheidt machines.

B.S.A. Tools Ltd, of Mackadown Lane, Kitts Green, Birmingham 33, also exhibited a fillet-rolling machine. While primarily intended for rolling crankshafts, it can also be used for other components. Any highly stressed shaft can be substantially improved with regard to its properties by deep rolling the fillets at abrupt changes of section. The drive in this instance is, therefore, to the component being treated, which is mounted between a driving headstock and a tailstock, both hydraulically operated. Control is by means of a sequencing system regulating the hydraulic pressure to the rolling units and a system for counting and determining the number of revolutions of the workpiece. Loading and unloading is effected manually, but automatic handling can be provided easily since the loading attitude of the crankshaft can be pre-set and the rolling units pre-positioned. Lubrication is automatic during the rolling operation.

This machine, with a main drive motor of 10 h.p, can be fitted with up to thirteen rolling units for a six-throw,




*Arrangement of Hegenscheidt fillet-rolling machine*

**A** *charging mechanism;* **B** *rolling units;* **C** *hydraulics motor;* **D** *lubrication pump;* **E** *driving motor;* **F** *control panel;* **G** *hydraulic pressure gauge;* **H** *master crankshafts*

seven-bearing crankshaft having crank strokes up to 5 in and an overall length of 36 in. Each rolling unit is supported by a linkage on a pivot shaft and is counterbalanced by a weight suspended on a roller chain. Push-button controls are provided for starting the driving motor, starting the hydraulic pump motor, advancing the work centres, and closing the rolling units. The driving motor runs continuously, and the hydraulic unit provides a low pressure for closing the rolling heads and an adjusted high pressure for the actual rolling operation. When the centres are advanced the work is picked up and axially located in relation to the rolling units. After the loading of the component and the closing of the rolling heads, a hand lever is depressed to start an automatic cycle that energizes the main spindle drive clutch, applies the high rolling pressure in a predetermined sequence to the rolling heads, relieves the high pressure when the rolling operation is completed, and brings the component to rest precisely in the load-unload position. A special low-pressure clamp is applied automatically to hold this position, the rolling heads open, and a green light indicates the "end of cycle" condition.

**Self-contained, automatic, drilling head**

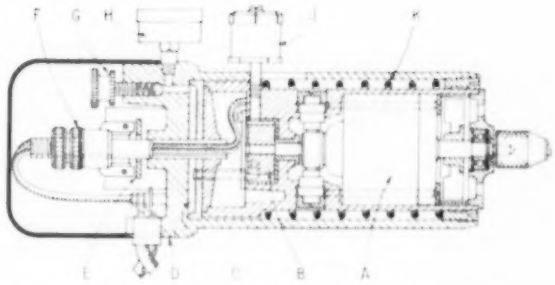
A small drilling unit manufactured by the Dumore Company, of Racine, Wisconsin, U.S.A, facilitates the rapid production of small diameter holes. Operating on the so-called "resistance drilling" principle, it has a drill capacity up to $\frac{1}{2}$ in diameter and is powered by a 1·6 h.p. fan-cooled motor running at from 2,500 to 7,500 rev/min. The motor performs a dual role. It drives the drill and also generates a supply of air under pressure to apply the feed; the drill chuck and a small, sliding vane-type compressor are mounted on the opposite ends of the armature shaft.

Air drawn in by the compressor, through an intake regulator and a filter, is delivered to the head of the motor-compressor assembly which is axially slidable in the main cylindrical body of the unit. In the clearance volume between motor and body, pressure is built up and maintained at a value determined by an adjustable relief valve and indicated on a dial gauge. Under the influence of this pressure the motor assembly is displaced from the body, against an interposed helical return spring, to apply feed to the drill. The feed stroke, to a maximum of $1\frac{1}{8}$ in, is set by means of a screwed adjuster and can be controlled to within approximately 0·004 in. When the pre-set depth has been drilled the motor assembly uncovers an exhaust port in the body, feed pressure is released, and the return spring withdraws the motor assembly to the starting position.

Resistance drilling is claimed to be the only method giving full consideration to the structural weakness of small diameter drills. By applying a feed pressure within the strength of the drill, the hardness of the material determines the drill speed, rate of feed, and production output. It is not commonly realized that as drill diameters decrease so the length : diameter ratio, directly affecting susceptibility to breakage, rapidly increases. Referring to American practice, a 0·125 in diameter drill has a ratio of 22·5 : 1, yet for a 0·0135 in diameter drill the ratio is 55 : 1.

When drilling small diameter holes to depths greater than three to five times the drill diameter it is of advantage to withdraw the drill periodically to effect chip clearance. For such duties a repeat cycle timer, electronically controlled and solenoid operated, is available. Drilling time and the duration of the pause on withdrawal can each be pre-set on dials. The cycle repeats until the hole is drilled to the required depth or the workpiece is penetrated.

These drilling units are $14\frac{1}{2}$ in long, $4\frac{1}{2}$ in diameter, and weigh $17\frac{1}{2}$ lb. They can readily be built into existing or special equipment, and standard brackets and mountings are available. Operating advantages claimed over conventional drill press applications with sensitive or power feed, drawn from actual installations in the U.S.A, are 200 to 300 per cent increase in production rate and 90 to 100 per cent decrease in drill breakages. The British agents are Gaston E. Marbaix Ltd, London, S.W.11.




**A** motor assembly; **B** air compressor; **C** pressure chamber; **D** exhaust port (actual position in rear of this view); **E** hand control switch lever; **F** stroke adjustment; **G** pressure-regulating relief valve; **H** air pressure gauge; **J** air feed regulator and intake filter; **K** return spring

*Dumore automatic, pneumatic feed, drill head*

**Roller-burnishing machine**

A special-purpose model in the range of roller-burnishing machines manufactured by Wilhelm Hegenscheidt KG (agents Elgar Machine Tool Co. Ltd, Acton, London, W.3) is available for superfinishing the stems of internal combustion engine valves. It is totally enclosed to exclude dust during the rolling operations and can handle work with stems from $\frac{1}{4}$ in to $\frac{7}{8}$ in diameter and from 3 in to 6 in long. A 1·5 kW, 1,410 rev/min motor rotates the drive roller at 450 rev/min, giving a peripheral speed of 270 ft/min. Hydraulic pressure is generated by a 2 kW motor and pump and, operating at a pressure of 50 atm (735 lb/in$^2$), the radial pressure on the rollers is 4,200 lb. Floor space occupied is only 31 in × 43 in and the machine is 56 in high.

*Special Hegenscheidt machine for roller-burnishing valve stems*

*Speedometer drive spindle in En 8, grooved on Steinle thread generator*

Fully machined valves, loaded on a feed rail, are fed individually to the working position by a release mechanism and a loading device, both of which are actuated by solenoids. The combination of micrometer setting of the burnishing rollers and constant hydraulic pressure enables close limits on the valve stem to be maintained consistently. The rolling process reduces the stem diameter by 0·01 mm and leaves it with a mirror finish.

Treatment is automatically terminated by a limit stop mechanism, which simultaneously opens the rollers. The inclined arrangement of the rolling unit enables the valve to slide easily into the discharge chute by gravity. Automatic operation is effected by electro-hydraulic sequence controls, each of which can be individually hand-operated when setting the machine. An efficient cooling and lubricating system is provided, the lubricant being fed to the work through the burnishing roller bearings after passing through a micro-filter. Superfinish by rolling normalizes and stabilizes the workpiece material and produces a hard, wear-resistant surface.

**Thread rolling**

Although designed for the production of accurate screw threads, the B.S.A.-Steinle centreless thread generator is adaptable for other purposes. At the Exhibition, it was demonstrated, with a bowl-type hopper and automatic feed, forming a helical oil groove on speedometer drive spindles. An illustration shows the spindle as received from a bar-type automatic, as roll-grooved on the Steinle machine, and as finish-ground on a centreless grinder. The reduced-diameter end portion is serrated in a further rolling operation to receive a pressed-on nylon pinion.

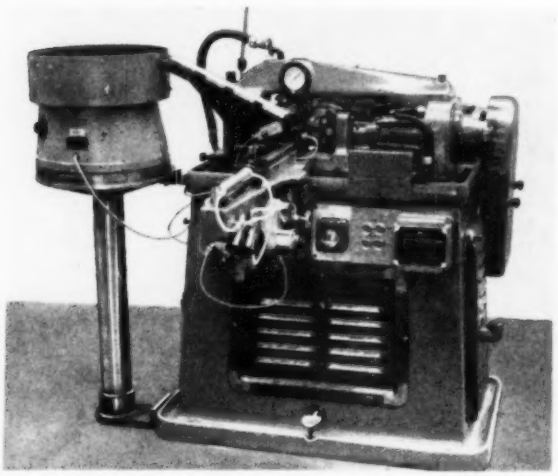
On this machine the rolls are mounted on spindles running in needle and standard roller bearings and are additionally supported by outboard roller steadies. One roll rotates on a stationary axis while the other is mounted on a slide which is fed inwards hydraulically to engage the workpiece and apply the necessary pressure for the rolling operation. During this operation the workpiece is supported on a rest between the rolls, similar to that used on centreless grinding machines. This feature offers advantages over more conventional designs, since cylindrical dies in conjunction with a steplessly variable hydraulic feed give, in effect, a die of infinite length and enable the rate of rolling to be closely controlled to suit the properties of the workpiece material.

In the set-up illustrated, the components are manually loaded into the bowl feeder and thereafter the cycle is fully automatic. At the top of the bowl spiral they are sorted and then fall, in correct position, down a cascade chute to a pneumatic loading mechanism. This is timed by micro-switches to operate in conjunction with the work slide.

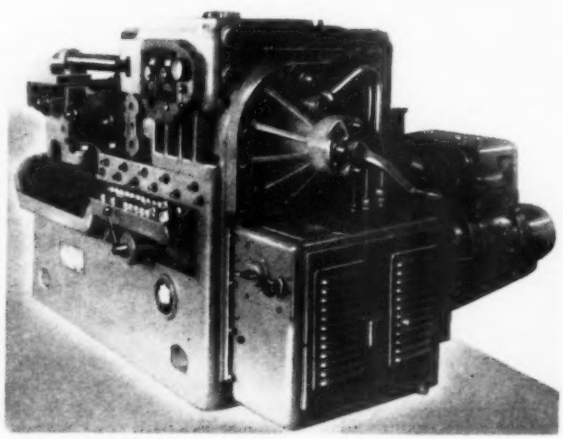
When the work slide returns to the rest position after rolling, a micro-switch actuates a solenoid air valve which moves a loading slide forward. A loading bar on this slide pushes a component from the cascade chute, along a guide channel, and into correct position on the work rest, pushing out the finished component into a delivery chute. The forward motion of the loading slide initiates the operation of a hydraulic valve that causes the roll slide to advance for rolling. Immediately it commences to feed in, a micro-switch cuts the solenoid air valve and the loading slide returns to its retracted position ready for a successive operation. Rate of production for the component illustrated is 20 pieces/min. The machine is handled by Burton Griffiths and Co. Ltd. (B.S.A. Tools Division), Mackadown Lane, Kitts Green, Birmingham 33.

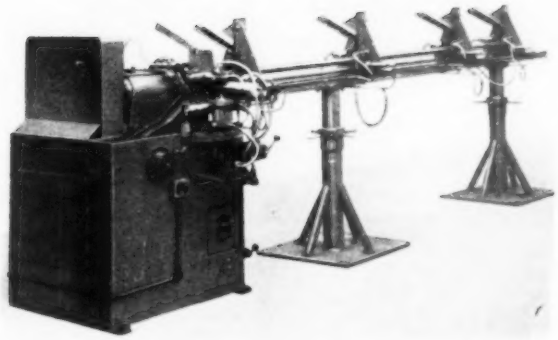
A new Pee-Wee thread generator, also factored by Burton Griffiths and Co. Ltd, has a work capacity of from 10 to 175 mm diameter, thread length up to 250 mm in plunge rolling and 2,000 mm in through rolling, and thread pitch up to 16 mm, although all these values cannot be realized simultaneously by the plunge method. Working pressures are steplessly variable between 1·5 and 50 tons. Total drive capacity of approximately 22 kW is from a special quick-reversing motor through a backlash-free gear mechanism with hardened and ground helical gears. An electro-

*B.S.A.-Steinle centreless thread generator with automatic loading*

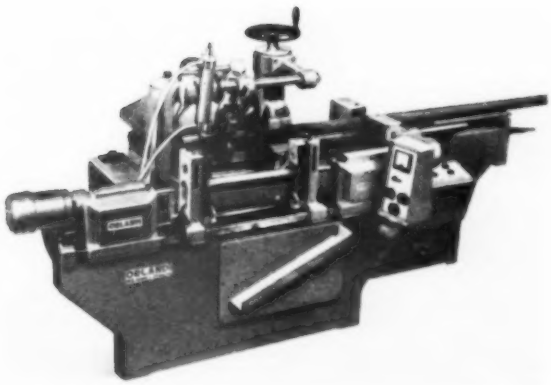


*Pee-Wee Model P50 thread-generating and cold-forming machine*





*Voucher Model 57 bar cut-off machine with magazine feed equipment*



*Orlandi SRHC 320 Elettromatic-Center sawing and centring machine*

mechanical, rapid-acting brake is fitted for changing the direction of rotation.

Motor and gear are built as a unit and bolted up to the rear of the main machine. From the gear unit the drive is transmitted to the roll spindles by telescoping, universal-jointed shafts. Roll spindles are each supported at both ends in solid roller, anti-friction bearings and the roll bores are 90 mm diameter and 260 mm long. Hydraulic control gear, grouped and enclosed as a unit on the right of the machine, provides a rapid traverse at 8·5 mm/sec, operating traverse adjustable from 0·5 to 1·8 mm/sec, and rapid return at 31·0 mm/sec. The roll speed range is variable from 10 to 45 rev/min, and rolling times can be adjusted between 1·0 sec and 6·0 min. Intervals can be set from 0·5 sec to a maximum of 1·0 min.

While thread rolling is the most common application of such machines, universal models suitably set up and equipped are capable of a very wide range of operations. Instead of being dubbed "thread-rollers" it would seem they could more aptly be described as "roll-forming machines". In addition to the rolling, either by plunge or through methods, of taper, Acme, round or saw-tooth threads, worms, helical gears, splines, serrations, grooves, knurls and cross-knurls can be rolled. All types of burnishing operations can be performed; for improving surface quality of cylindrical components, for rolling grooves in shafts to reduce notch effect, for simultaneous burnishing of bearing surfaces and straightening of shafts, for straightening of valve stems, for the simultaneous stem straightening and heading of valves, and for the rolling of collars on shafts.

With precision bearings on the roll spindles, roll sizing can be carried out to a tolerance of plus or minus 3 microns on diameter. Special machines having a three-roll arrangement are used to form hollow components. In this instance, the workpiece is induction heated—the only departure from the cold-forming practice.

**Cold sawing machines**

Sawing machines, commonly in the past relegated to an old corner in a shop and regarded as auxiliary tools, are now receiving more attention and are appearing as production machines. Probably the wider use of automatic copying lathes and chucking automatics has exerted an influence in this respect.

One such machine, the "Voucher-57", manufactured by Voucher Ltd, Intown, Walsall, is air-actuated from the shop line at 80 lb/in$^2$ and is available for either semi-automatic operation or fully automatic continuous operation with a magazine-type bar feed, as illustrated. Capacity when using the largest saw blade that can be fitted, 12 in diameter, in mild steel and non-ferrous metals is bars to 2½ in diameter or 2¼ in square and heavy-gauge tubes to 2½ in outside diameter. Typical cutting-time cycles are ⅝ in square brass, 2 sec; ¼ in B.S.P. heavy tubes, 9 sec; and 2 in diameter mild steel bars, 40 sec. The stock is cut dead square and accurate to length, within the limits ±0·003 in, up to a recommended maximum of 12 in for automatic feeding.

The saw spindle is driven by a 2 h.p. 950 rev/min motor through helical reduction gearing and vee belts. Single-speed machines are available with saw speeds of 36 rev/min for mild steel solids and 72 rev/min for light-gauge tubes; a two-speed machine with 18 and 36 rev/min for high-tensile steels; and a general-purpose machine equipped with a Haines variable gear for speeds ranging from 24 to 60 rev/min. The sliding saw head and its power unit is mounted on hard chrome-plated and ground bed bars and the feed motion is controlled by an oil dashpot.

Grip and feed of the stock material are air-operated. The bar is held in a duplex-grip workholder to ensure that it is cut cleanly and free from fraze. This feature also enables the whole length of the bar to be used. Short ends are automatically ejected. Supporting the bar magazine are two or more tubular stands, adjustable both horizontally and vertically to suit the material being handled.

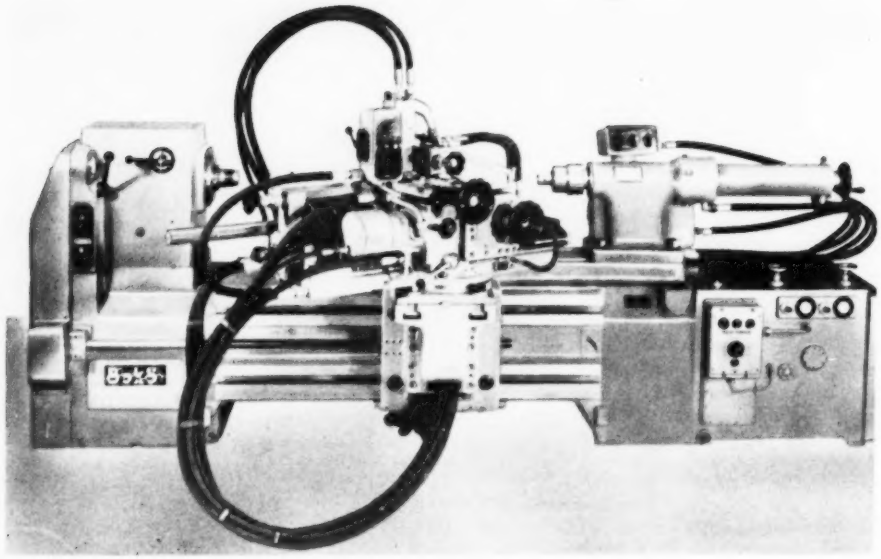
Orlandi, of Milano-Bresso, the largest manufacturers of sawing machines in Italy, has introduced a new combined sawing and centring machine, designated "SRHC 320 Elettromatic-Center". It has a sawing capacity up to 4¼ in diameter bar, but is designed in particular for the cut-off and centring of shafts and spindles up to 20 in long from bar up to 2¼ in diameter.

Fitted with a 12½ in diameter × ⅞ in saw blade, the spindle is driven by a 4 h.p. motor, and four speeds are available by a change-gear mechanism. A 2 h.p. motor drives the hydraulic pump for bar feed, clamping, saw feed, and work transfer cylinders. Centring unit motors are each rated at 0·6 h.p. Accuracy in both parting off and centring is held with tolerances of ±0·002 in.

Automatic sequencing of operations is as follows:

1. Stock is fed to pre-set length
2. Stock bar is clamped
3. Saw head advances and cutting commences; sawn part is centred; feed clamp returns to start position
4. Fast return of saw head to start position; part just sawn off is released and transfer movement commences
5. Sawn and centred part is ejected to chute.

Solenoid valves determine the timing of various cycles under either fully automatic or manual, push-button, control. Cycles may be arranged for intermittent or automatic sequence cutting, cutting and centring both ends, or cutting



*The newly introduced, Boko D 35 H semi-automatic spinning and flow-forming lathe*

and centring only one end. Multiple bar cutting is possible by means of a stacking device. Substantial savings of production time are effected as sawing and centring operations are performed simultaneously. Typical production times for sawing and centring 2 in diameter bar range from 25 to 50 sec for steels of 30-ton to 50-ton tensile respectively.

Agents for this and other Orlandi machines are the Addison Tool Co. Ltd, Marshalsea Road, London, S.E.1.

**Tilt-head surface grinder**

Numerous features of control facilitate operation of the Model No. 24 vertical, rotary-type, surface grinder built by the Mattison Machine Works, Rockford, Illinois, U.S.A, and exhibited by Gaston E. Marbaix Ltd, the British agents. It is available in various specifications to meet individual requirements. Any workpiece or group of parts occupying an area of 38 in or alternatively 48 in diameter, and up to 18 in or alternatively 24 in high, can be handled. Work tables may be fitted with 30 in, 36 in, or 42 in diameter magnetic chucks. Table drive from a 2 h.p. or 3 h.p. motor is through a helical pinion and ring gear, giving a speed range from 8 to 32 rev/min.

Grinding wheels of either cylindrical or segmental types may be either 18 in or 20 in diameter. Wheelhead feed may be by hand wheel graduated in steps of 0·0001 in, or by a continuous automatic feed, powered by a $\frac{1}{2}$ h.p. motor, at a rate variable from 0·005 to 0·165 in/min.

An outstanding feature is the provision of a tilting movement for the wheelhead. This is air-operated, with a simple switch control, to tilt the spindle a predetermined amount from the vertical for initial rapid stock removal. Reversal of the switch immediately returns the spindle to the vertical position for finish grinding. It is claimed that as faster down feed can be employed for roughing with the wheel tilted, production times can be lowered by as much as 50 per cent in some cases.

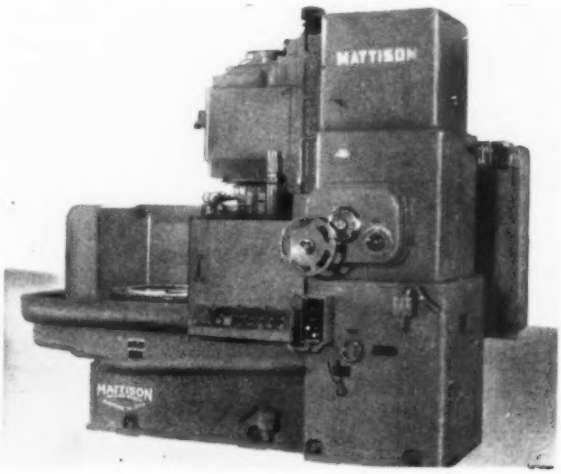
**Spinning and flow-forming**

Long specializing in spinning and flow-forming lathes, Bohner and Köhle Maschinenfabrik, Esslingen/Neckar, Germany, have introduced a new series of semi-automatic machines with full hydraulic operation of slides, tailstock, and copying mechanism. Designated D 35 H and D 50 H, the machines can, in the majority of cases, be operated by unskilled personnel since the automatic cycle only requires the machine to be loaded and unloaded.

Referring to the smaller model, D 35 H, centre height is $13\frac{1}{4}$ in and spindle speeds are steplessly variable from 280 to 1,200 rev/min, or 45 to 280 rev/min with the back gear engaged. Distance between centres is either $40\frac{1}{2}$ in or 52 in, and the tailstock traverse is 16 in. Tailstock sleeve and clamping movements can be selected from slow, normal and rapid traverse rates. After a rapid traverse the rate can be automatically changed to slow approach before engaging the work blank. Initially, clamping pressure is low and the blank can be adjusted on the holder.

When changed over to clamp finally the blank or the workpiece to the spinning chuck the pressure is raised to 8,000 lb/in$^2$. Three rates of feed are also available for the longitudinal and cross slides. Spinning rollers of single- and double-bearing types for various forming processes are carried in special adapters in a boxed mounting on the main slide. These rollers can be interchanged by turning tool holders which are used when the machines are required for dressing or cutting hollow parts or producing spinning mandrels. British agents are Elgar Machine Tool Co. Ltd.

*Mattison No. 24, tilting-head, rotary surface grinding machine*



# A-MP "FASTON" CONNECTORS

*A Comprehensive Range of Solderless, Machine-attached, Electrical Terminals of Push-on Types that Effect Substantial Economies in Assembly Times*

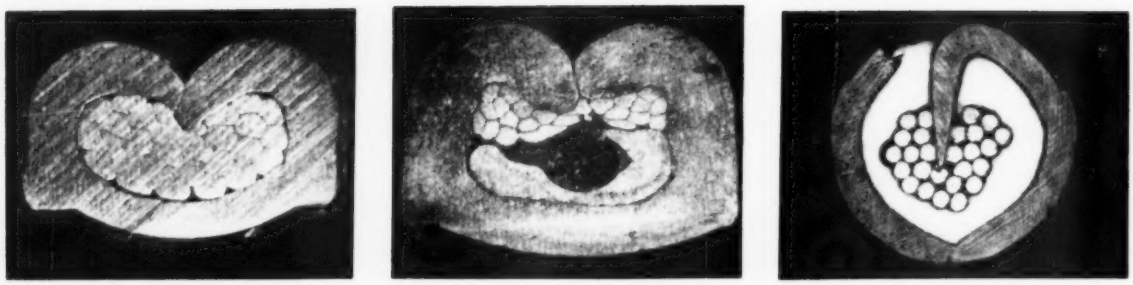
To cite an old adage, "the speed of the fleet is the speed of the slowest ship". So it is in modern production. In a machining line, the operation taking the longest time determines the cycle time for the whole line. It is true, also, for the assembly line, where the longest operation will necessarily govern the conveyor speed. The problem can be alleviated by duplicating the machines or increasing the number of men engaged on a particular operation, but this expedient raises costs and absorbs factory space. To increase productivity, it becomes necessary to improve both machines and methods so that operations are simplified, and this may entail modification or redesign of the component or assembly being manufactured. For worthwhile advance it is essential, of course, for progress to be effected simultaneously in both production and assembly operations, or the one will nullify any improvement in the other.

From early days, the wiring-up of electrical equipment had been a time-consuming operation and only slowly were improvements effected in the crude methods of twisting together bared wires and of looping wires under the heads of screws. The use of solder to secure twisted wires and to attach ring- or spade-type stamped terminals marked an advance, since it conferred both electrical and mechanical advantages. Solder, however, brought in several disadvantages, called for certain precautions, and required a varying degree of operator skill in application. Unless special care was taken, the heat used for soldering was likely to damage insulation and could even anneal the terminal tongue. It was essential that the elements to be joined should be clean and free from grease, or no reliance could be given to the connection in service. Fluxes were liable to be corrosive to metal elements and to have deleterious effects on insulation.

With the advent of mass production of commodities, each requiring a large number of connections, a radical change that materially reduced time and cost factors was the introduction of mechanically joined connectors. These were variously designated as "swaged", "crimped", "pressure", or "solderless" terminals. They require no heat, no flux, and call for no skill from the operator. It is necessary that the applied pressure is of a value that will preclude any possibility of the contact established between the conductor and the terminal being affected by springback or subsequent relaxation of the metal elements. Connections made by machine have the pre-set appropriate dimensions, which are maintained consistently and gives a uniformity not otherwise obtainable. Since heat, damaging to insulation, is not applied in pressure connections, it is possible to provide cable-insulation support or terminal-barrel insulation without additional operations.

Advocates of soldering methods have applied a vast amount of research to solders, fluxes, operating temperatures, wetting characteristics, oxide films, and corrosion problems. The proponents of pressure connections conducted research in the behaviour of metals under pressure, cold flow, extrusion, current-transfer properties of oxide

*Typical wiring harness, with a variety of crimped terminals and connectors, as supplied for a modern, flow-produced, private car*



*Micro-sections of various pressure connections. Left: On a stranded conductor. Centre: Connection of stranded cable to a steel wire conductor wound with copper wire and soldered before crimping, showing how the solder has flowed plastically. Right: Insulation-piercing terminal*

films, metal stability, and work-hardening of metals in swaging and crimping. These intensive investigations have demonstrated the electrical and mechanical soundness of pressure connections and also established their time-saving and cost-saving advantages. They meet the stringent requirements of the aircraft industry and tens of thousands are commonly used in a modern air liner.

Regarding the mechanical properties of a pressure connection, the metals have a crystalline structure and are deformed beyond their elastic limits. During compression the process is at first elastic—that is, fully reversible—and any relaxation of the compressive force would allow the metal to resume its original shape. If the metal is deformed beyond the elastic limit, it enters the "plastic" phase and takes on a permanent set. However, when the compressive force is relaxed, there is still a slow elastic recovery to some extent. Normally, when metal is compressed it does not deform uniformly throughout its bulk and, when the compressive force is removed, elastic recovery is greater in some portions than in others, giving rise to residual stress. This applies when a fastener is crimped to a wire or a stranded cable. It is the residual stresses that maintain the contact.

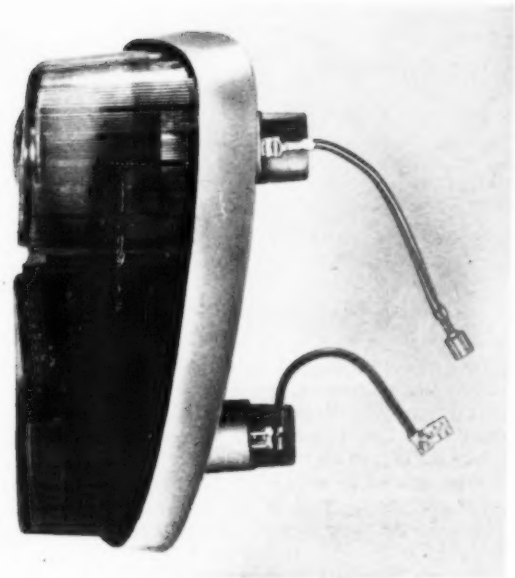
Contrary to some widely-held beliefs, rough surfaces give a better electrical contact than smooth surfaces. Copper surfaces in contact, for example, were found to have a much higher resistance if smooth and polished than similar surfaces that had been abraded. Furthermore, if the surfaces were exposed to oxidize in air for several days the difference became even wider. From this, it is inferred that the superiority of rough surfaces may be attributed to the break-up of oxide films as sharp asperities on the surfaces are forced into contact under compression.

Corroboration of this theory is provided if contacting surfaces are partially loaded, relaxed, reloaded to the previous value, and then the loading continued to the predetermined maximum. It will be found that resistance is decreased by the initial loading, and returns almost to the original high value by elastic recovery when the load is released. On restoring the load, however, the resistance is not again reduced until the previous loading value has been exceeded, when it again commences to fall to the expected theoretical values.

It is deduced from this that the asperities are flattened or blunted by the initial loading and there are but few of them to break oxide film when the loading is re-applied, until that loading has been exceeded. A further inference may be made; it is of more advantage to crimp in one continuous stroke than to take several steps and release the load in the intervals. In this connection, it should be remembered that metal contacts made by the initial loading may separate during the unloaded, recovery period, and that an appreciable oxide film can form on copper in a few milli-seconds.

Stranded conductors having a large number of strands

*One of the terminator machine lines in a plant producing wiring harness for automobiles*



*Tail unit with straight and flag-type FASTON connectors*

*Sealed-beam headlamp with three-circuit, push-on connector*

will expand sufficiently when the crimping pressure is released to provide good pressure contact. The so-called "barrel" of the terminal is initially formed in an open U-shape, and in the crimping operation the wings of the barrel are closed firmly and also the seam is forced down into the strands, coining them into a single mass. A crimp formed in this manner will carry the full rated capacity of the conductor. The open type barrel permits rapid assembly as it facilitates the entry of the bared conductor prior to crimping.

Insulation-piercing terminals are designed for attachment to stranded conductors without the need to strip the insulation. There are two types; in one, the edges of the wings of the open type barrel are formed with points which are turned in by the crimping tool and forced through the insulation and into the conductor. The other pattern, as shown in the micro-section, has tines punched from the lower run of the barrel. It is this type that is shown, in another illustration, attached to a high-tension lead for connection to a spark plug.

The main advantage of terminals of this type is the saving of the cost of stripping the conductor. Insulation must be soft enough to permit ready penetration by the lance or tine. Since only point contact is obtained, they are normally used where the conductor is not required to carry its full rated current. Where current requirements are small, mechanical rather than electrical considerations determine the conductor size, which in section may be many times that required to carry the current. In such instances the contact provided by insulation-piercing terminals will be more than adequate for the capacity required.

In solderless connections it is usual to design for the strength of the junction to approach but not exceed the tensile strength of the conductor. A crimp closed hard enough for the conductor to fail first under tension will usually reduce the conductor cross section excessively. When properly crimped, a connection will have the optimum combination of tensile strength and conductivity without the possibility of damage to the conductor. Accordingly, all crimping tools are designed with positive stops to prevent overloading.

Operating temperatures up to about 300 deg F will not

*Left: Two or three leads can be crimped and supported on a single FASTON connector. Centre: Burgess micro-switch with tab terminals for push-on connectors. Right: "Bullet" terminal and receptacle, and insulation-piercing connector for H.T. leads*

affect the performance of solderless terminals. Usually the properties of the cable insulation will limit temperature to a value lower than can affect the terminal. For temperatures higher than 300 deg F, the terminals can be produced from specially suitable base stock. Certain production ranges of terminals are available for high temperature applications, an example is A-MP STRATO-THERM terminals, insulated with a special heat-resistant plastics material and suitable for operation in temperatures of 380 deg F to 400 deg F.

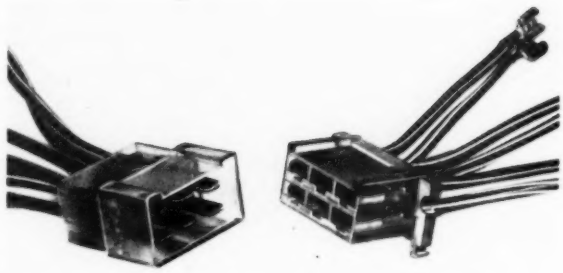
Crimping tools will eliminate most of the variables introduced by human error and judgment. Manually-operated hand tools, and pedal-operated bench tools are provided with ratchet devices which ensure that, once started, the pressure cannot be eased off or released until the full stroke to a positive stop has been completed. This precaution is essential, for reasons stated earlier, to obtain consistently

*The A-MP automatic terminator is powered by a $\frac{1}{4}$ h.p. motor*

good electrical contacts, and also to preclude the possibility —owing to operator fatigue towards the end of a shift or any other cause — of inadequately crimped connections being produced. Hand and bench-type, air-operated and hydraulically operated tools are also available. For high-rate production, electrically operated, pedal controlled, automatic machines with the terminals, supplied in continuous strip form, fed from a reel, are the most commonly used equipment. These leave the operator with both hands free for handling the work. Such machines are rapid in operation, and an operator with acquired skill can affix from 3,000 to 4,000 terminals per hour on individual leads.

All terminals manufactured by Aircraft-Marine Products (G.B.) Ltd, of Amplo House, Saffron Hill, London, E.C.1, are pressure connected and throughout the enormous range of more than 15,000 different types and sizes, the advantages of this method are well realized in the mass production of leads and harness. In the company's range of FASTON terminals, corresponding advantages are secured in the wiring of electrical equipment and controls.

FASTON units are of the "push-on" type, eliminating screwed or bolted terminals on the instrument or appliance and reducing labour time in assembly. These factors are unobtrusively revolutionizing the wiring of motor vehicles. Fewer separate parts are needed, the difficulty of assembling two or three leads on a single screw or bolt in an awkward location is obviated, and the wastage of such items as



*Six-circuit, insulated, FASTIN-FASTON harness connector*

screws, nuts and washers does not, of course, then occur.

Male and female elements of a FASTON connector, termed "tabs" and "receptacles", are produced in three sizes, identified as 250, 187 and 110, which indicate the width of the mating tabs in decimals of an inch. They are made either with or without an additional barrel for insulation support, this barrel being slightly offset to keep the conductor strands on the same axis as the crimp barrel. A variant is the "flag" receptacle, arranged at right-angles to the barrel. These are produced in the three larger sizes only. Tab connectors with crimp and insulation barrels similar to those of the receptacles are available for line splices, and plain tabs for building into or attaching to components are produced in flat or angled versions.

Receptacles are formed with inturned wings, the margins of which make a resilient linear contact with the mating tab. Rectangular perforations in the receptacle leave a transverse web bowed inwardly towards the wings. In this web is formed a simple detent which engages in a hole in the tab when that member is inserted to correct depth, and thus ensures firm retention. Illustrations of a harness and a machine applicator line are reproduced by courtesy of Ward and Goldstone Ltd, of Pendleton, Salford.

Terminals and connectors manufactured by Aircraft-Marine Products (Gt. Britain) Ltd. are in accordance with specifications and quality standards of the owner of the A-MP FASTON and STRATO-THERM trade marks, namely, A-MP Inc, Harrisburg, PA, U.S.A.

## British Sealed-beam Lamps

IT HAS been announced that British-made sealed-beam headlamps will be standard equipment on all Vauxhall 1961 Cresta, Velox, and Friary models for the home market. The lamps are manufactured at Corby, Northants, by British Sealed Beams Ltd, a new company jointly sponsored by The General Electric Co. Ltd., A.E.I. Lamp and Lighting Co. Ltd, and Joseph Lucas Ltd.

Rated at 60/45 V on 12 V, d.c. supply, as compared with existing bulb-type lamps which have a rating of 55/44 V on the same supply, the new lamps are standardized at 7 in diameter. A duplex, transverse, tungsten filament is sealed into an aluminized glass reflector, which is itself fused to the front lens. The unit, which may be regarded as one unified bulb, is gas filled and completely sealed. Electrical contacts are built into the rear of the lamp and are coupled to the power source by a three-circuit, push-on connector. The filament is located with meticulous precision relative to the focal point of the lens, and the relationship of reflector and lens is similarly closely controlled. As a result of this integration of filaments and reflector, there is no "blind" spot behind the filaments and, therefore, this very important reflecting area is not lost as it is with separate bulbs.

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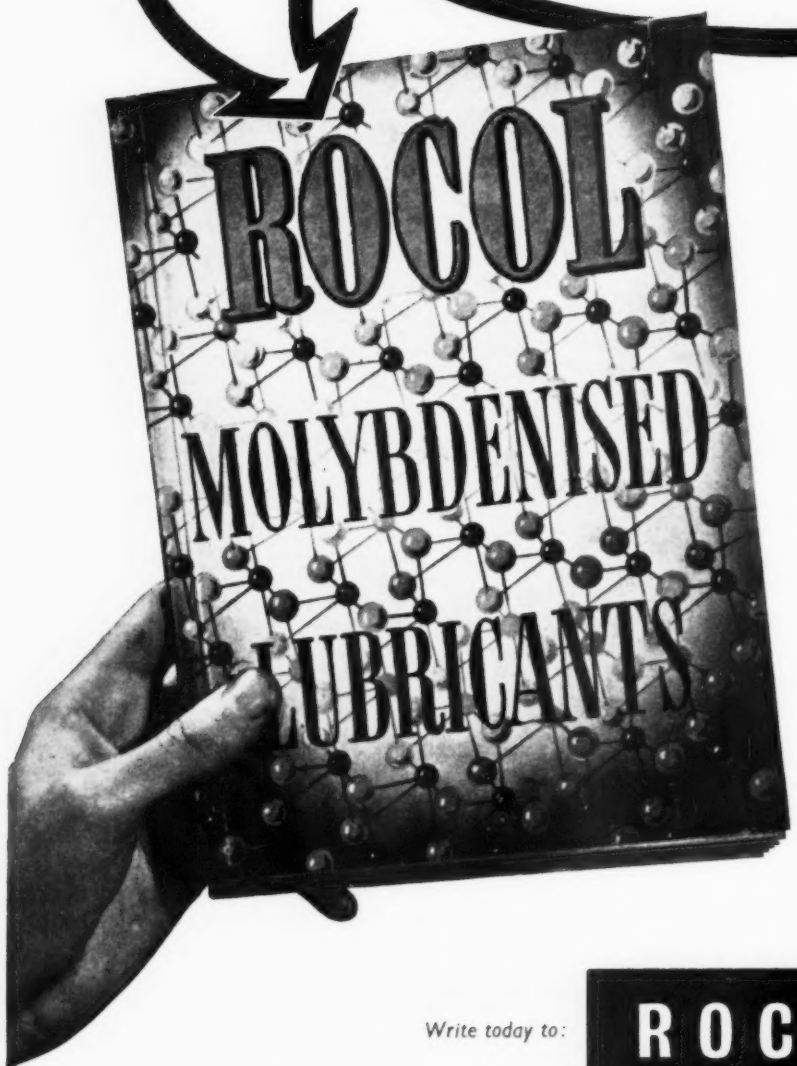


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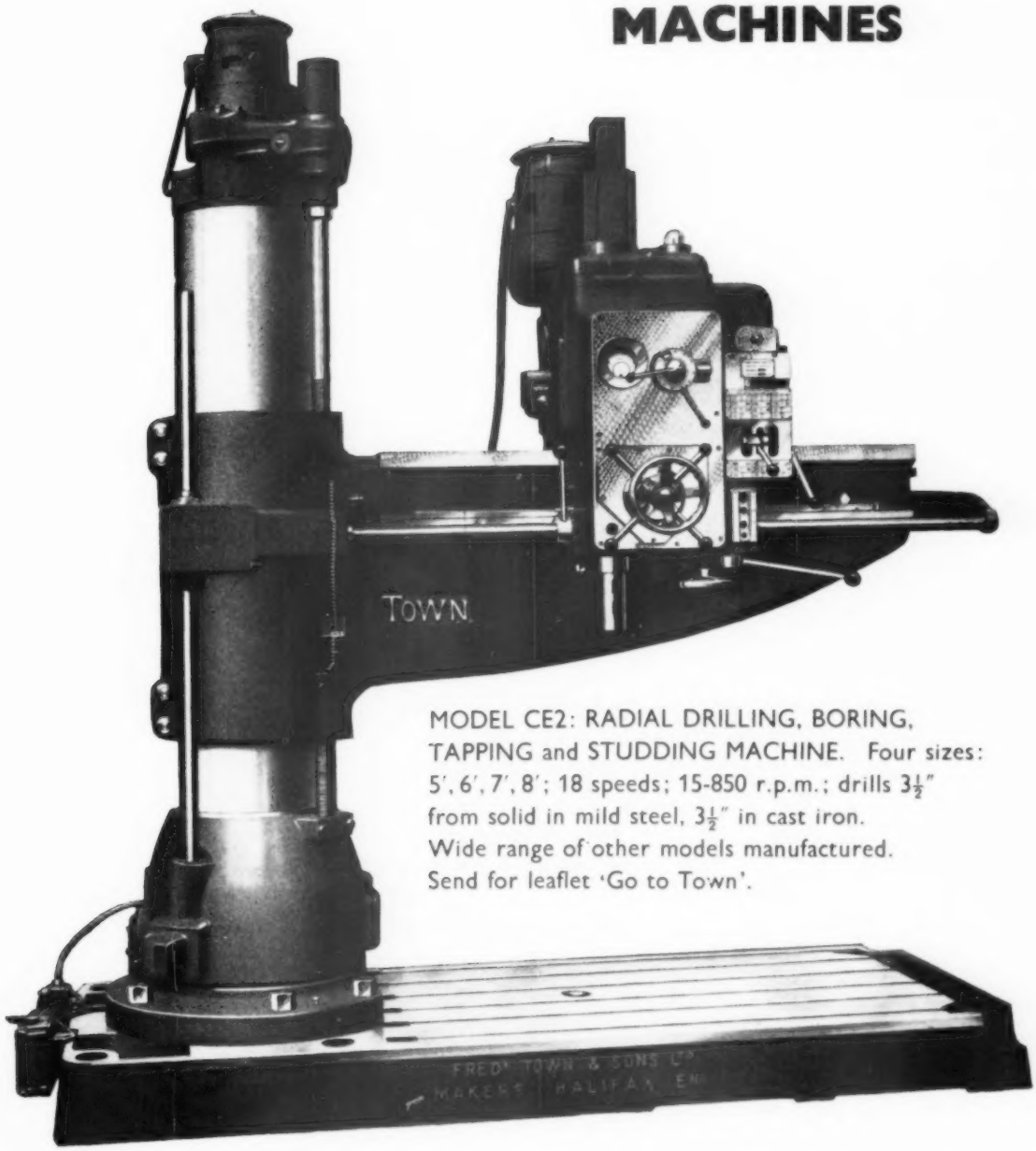


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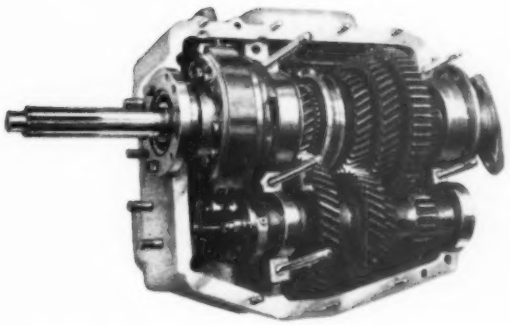

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Principal of the Transport Department

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J. BLUME T.

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*This is a translation of an affidavit drawn up by Dr. Daniel Cespedes, Notario Publico y de Hacienda.*

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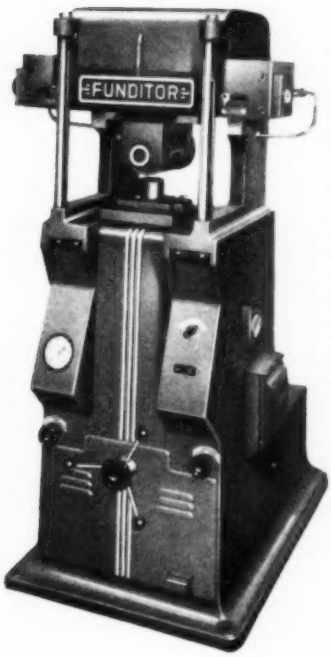


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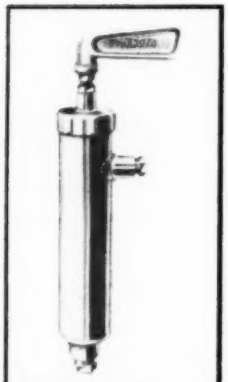

Among the one thousand and one small parts made by Benton and Stone Ltd., and all designed to make engines and industry operate smoothly, there are many Enots fittings and accessories ideally suited to automobiles and marine use, such as those illustrated here. May we send you our illustrated lists? Illustrations left to right: Breather, Side-lever Grease Gun, Throttle Control Ball Joint, Fuel, Oil or Water quick-action Filler Cap, Screw-down packless Fuel Cock, Engine Sump Pump.

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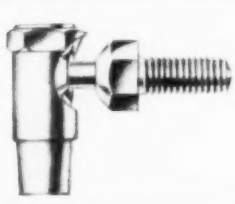

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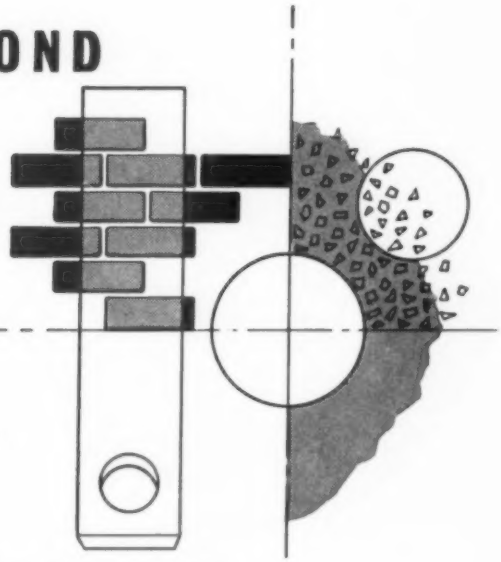

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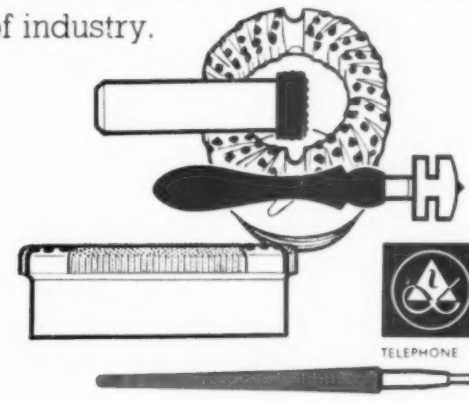

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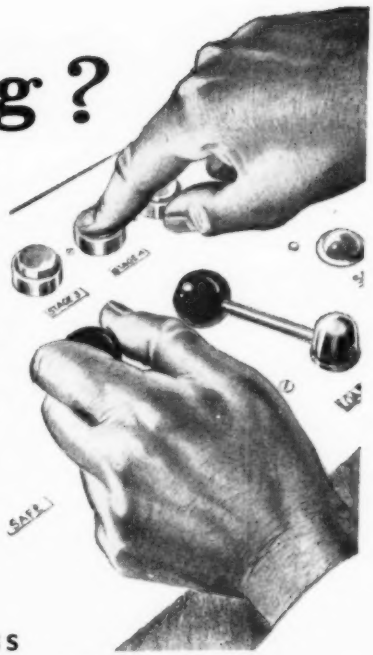

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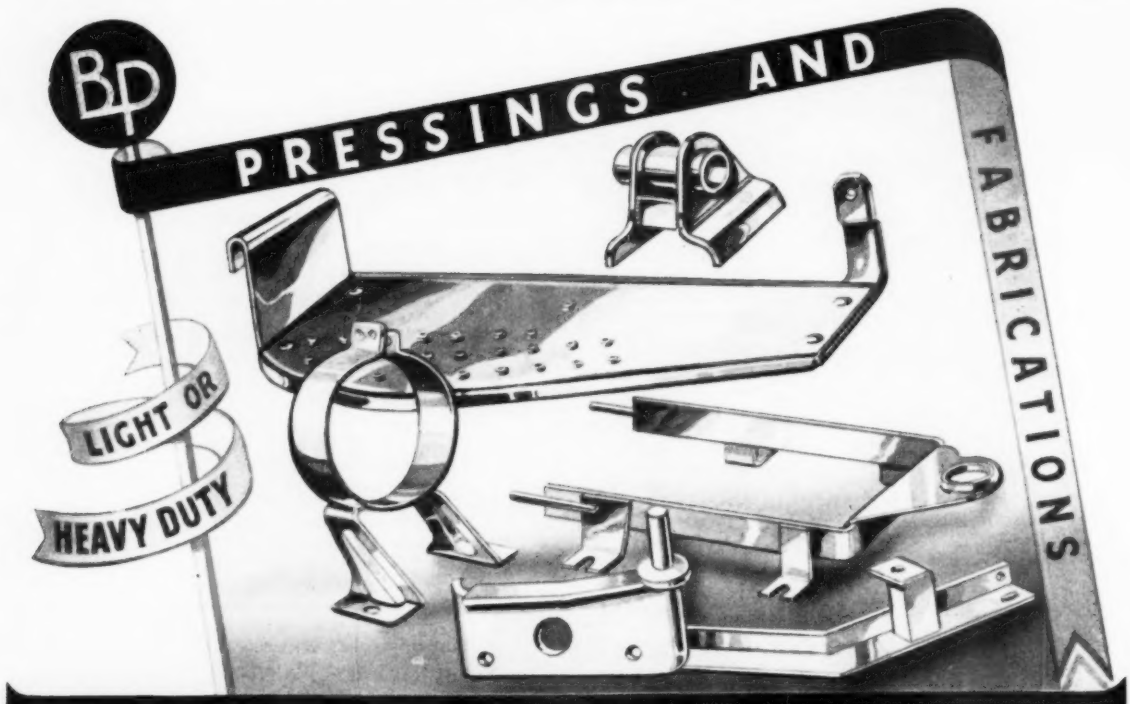


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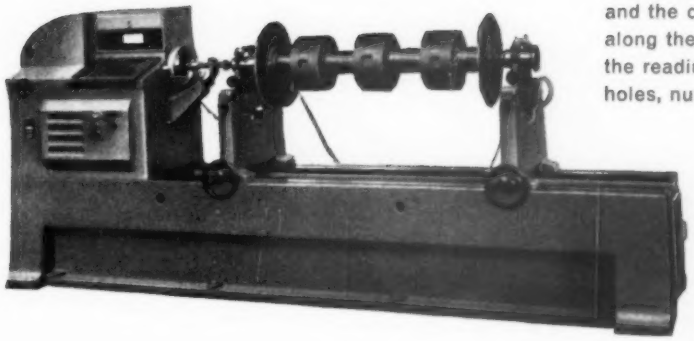

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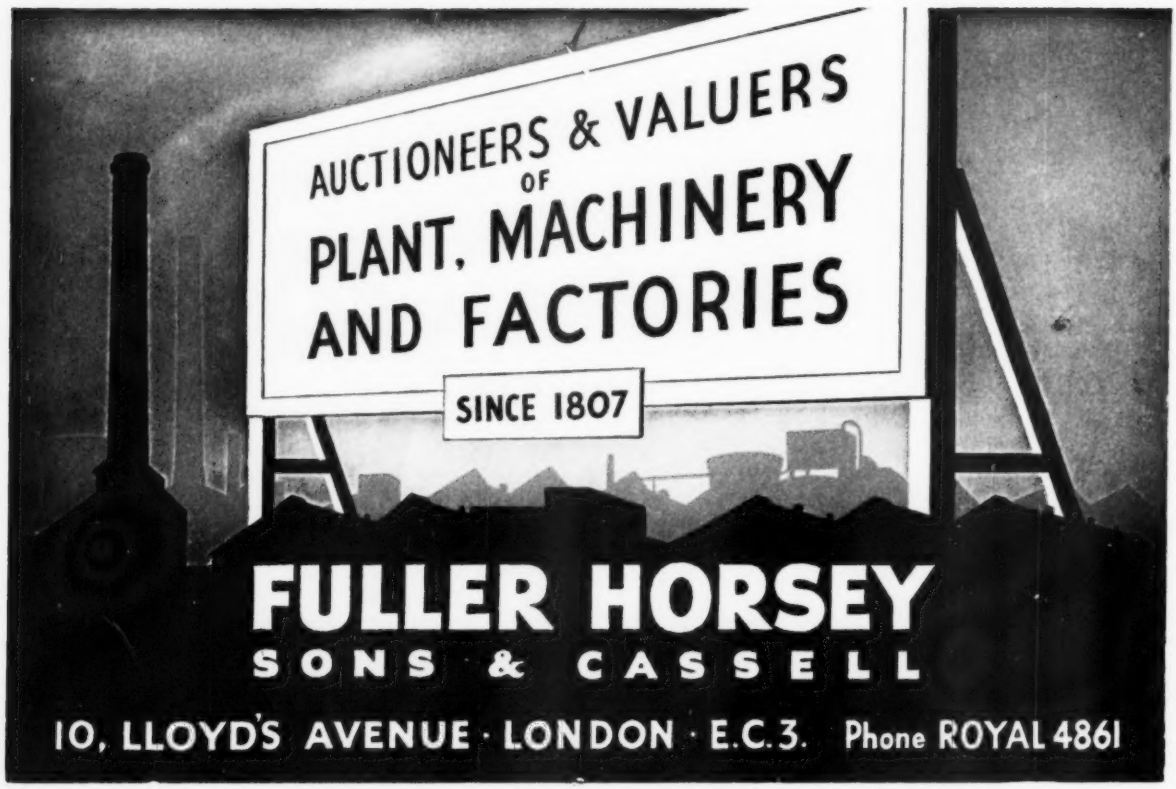


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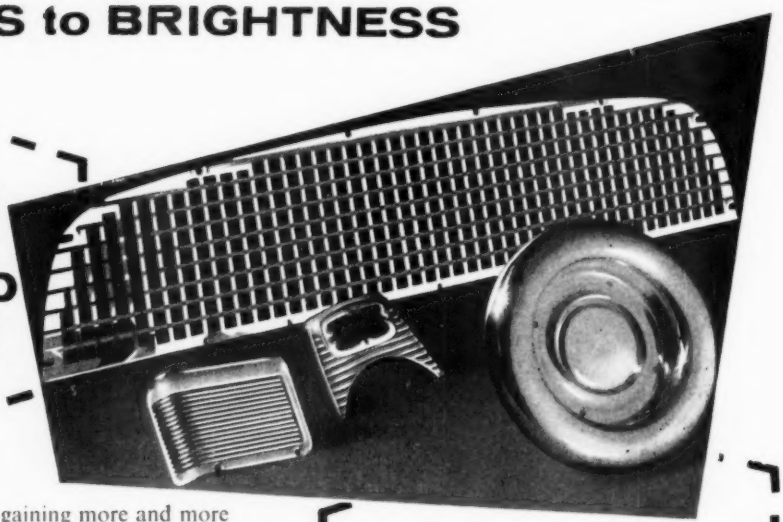

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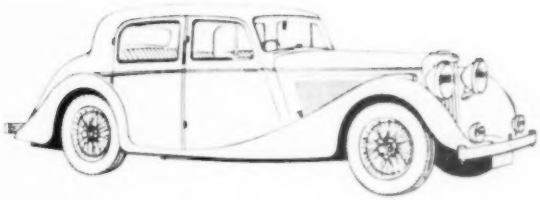

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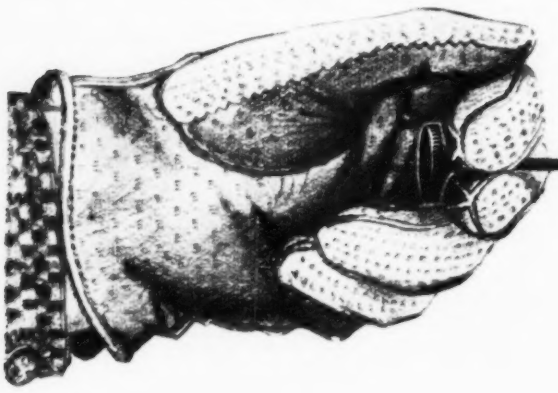

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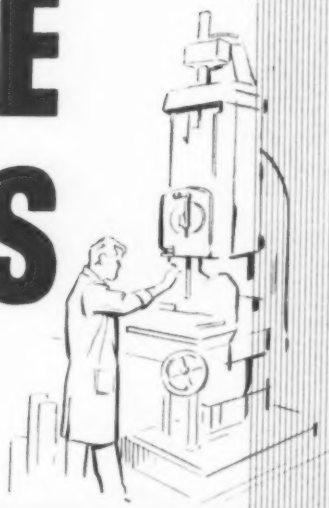

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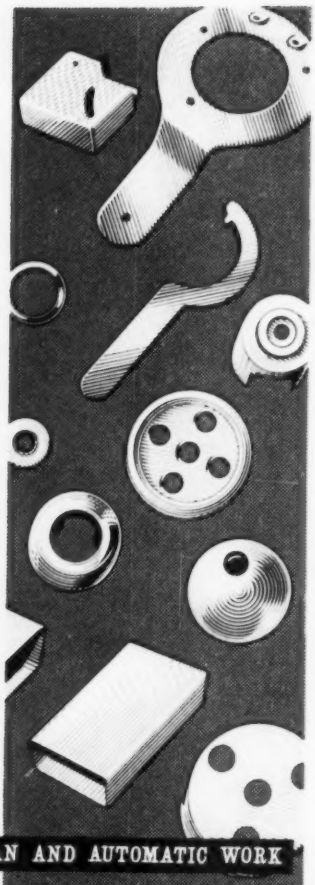

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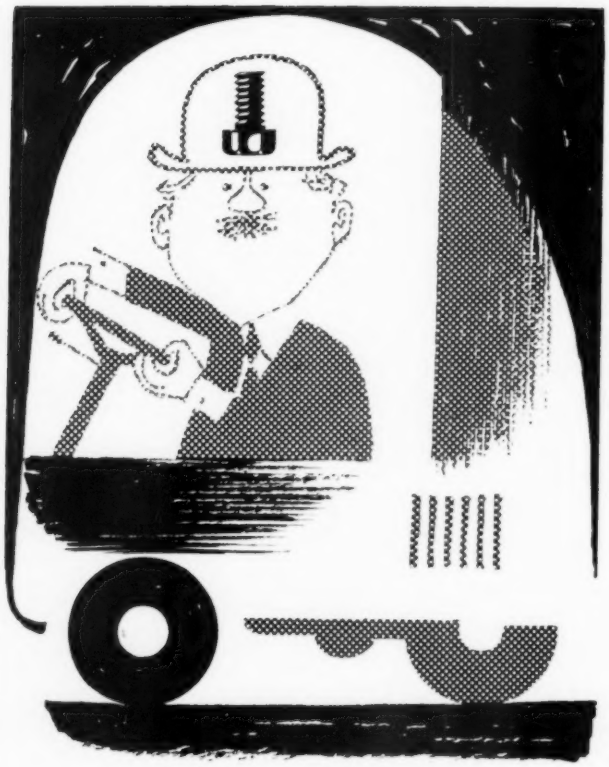

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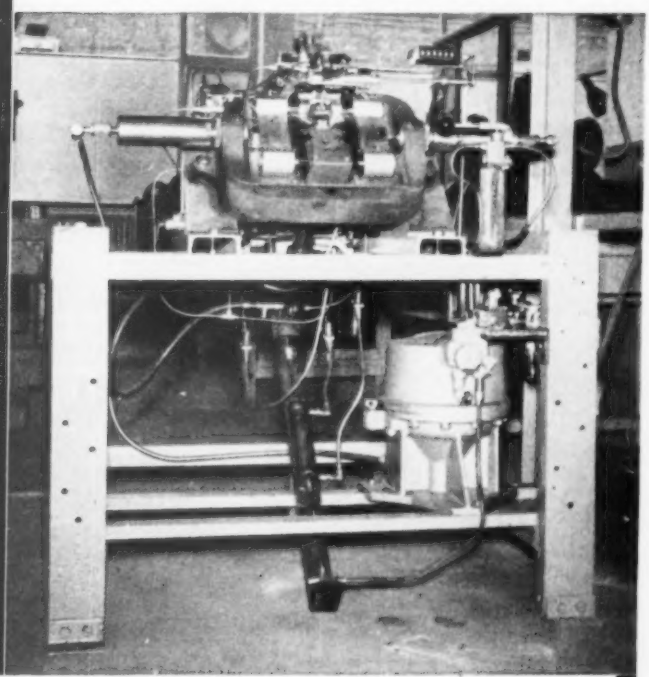

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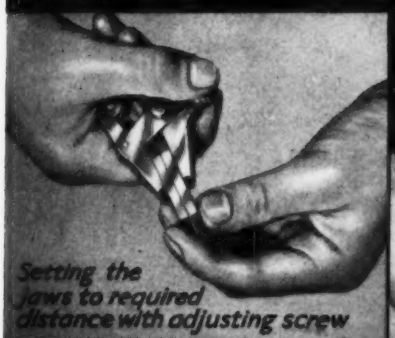
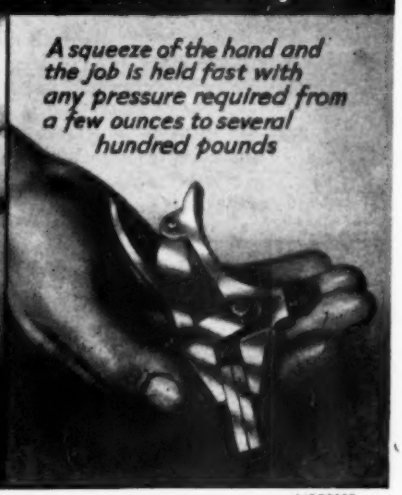


*Setting the jaws to required distance with adjusting screw*

- Jaws open to ½" always parallel
- Ratio of gripping pressure to hand pressure about 150 to 1
- Can be used as fixture or as hand tool
- Simple to use yet so sure in its action

*Presetting to required pressure with same adjusting screw*

TIME FOR SETTING & CLAMPING 10 SECONDS! DO YOU KNOW OF ANYTHING FASTER?



*A squeeze of the hand and the job is held fast with any pressure required from a few ounces to several hundred pounds*

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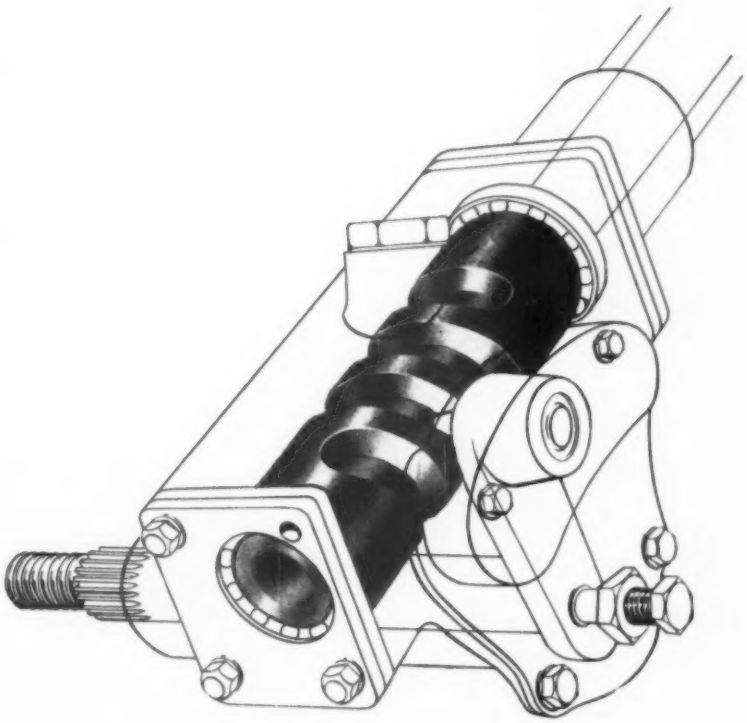

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**quality bars**

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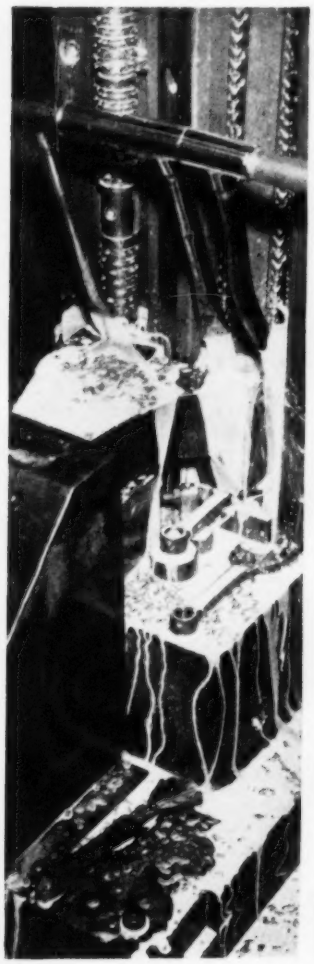

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*cutting fluids*

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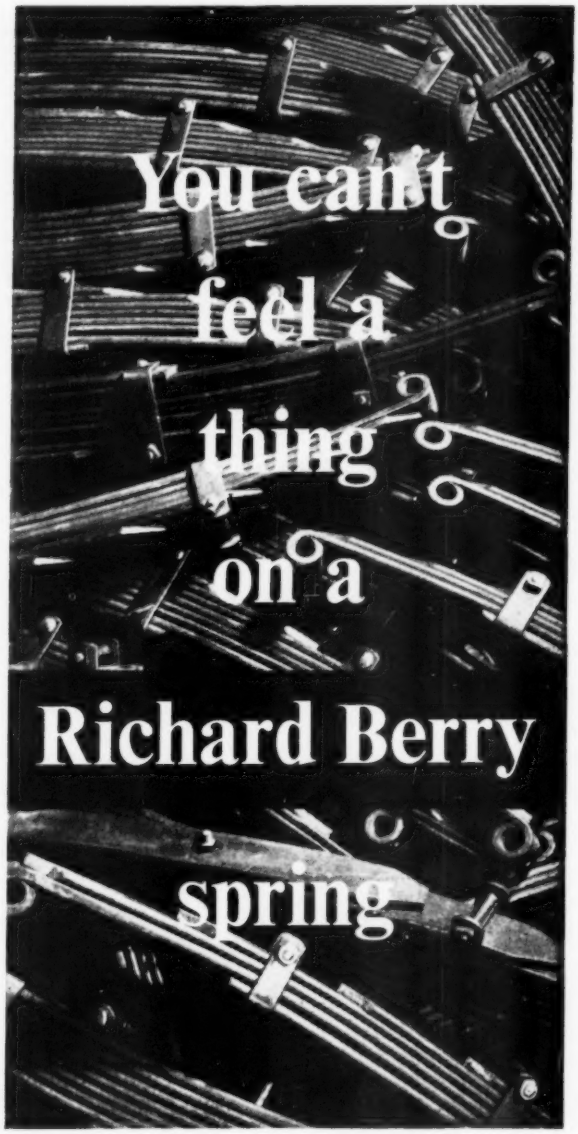


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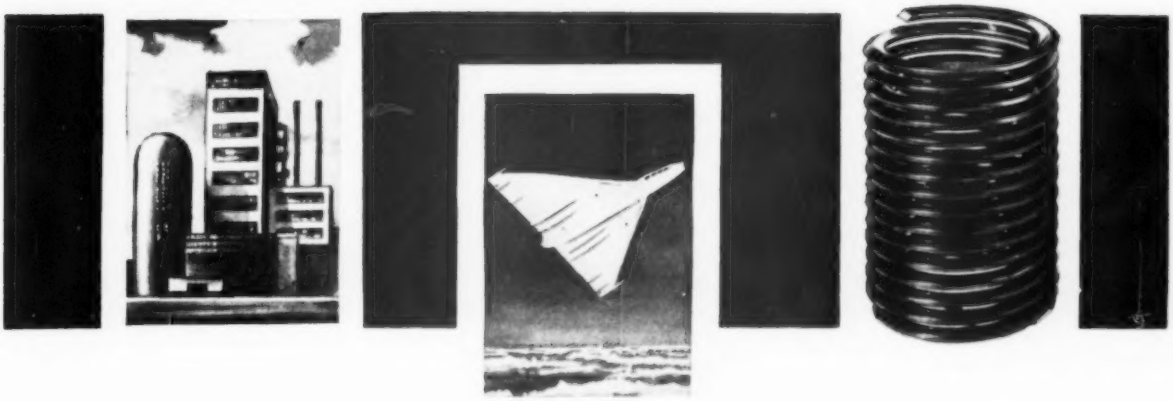

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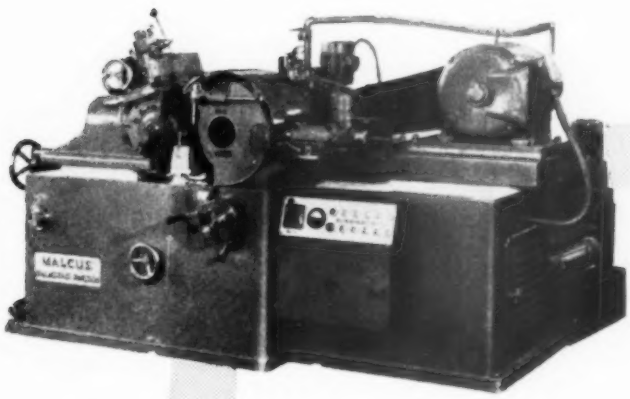


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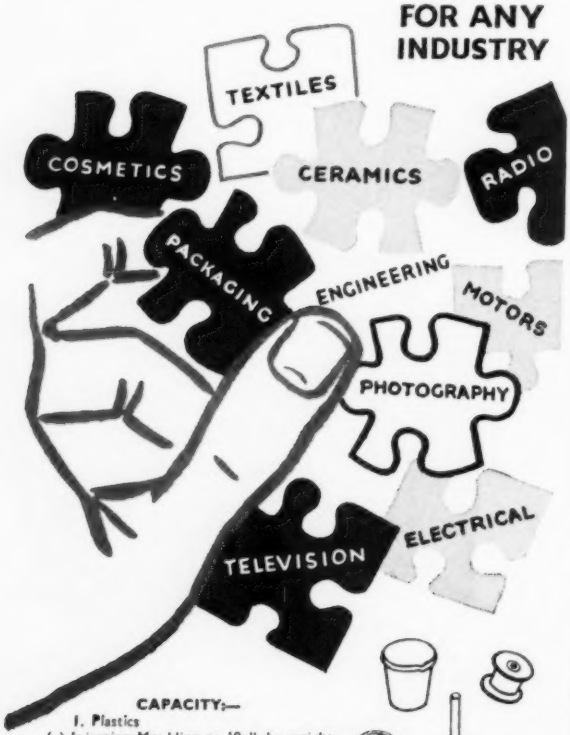


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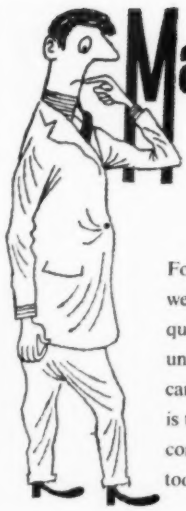

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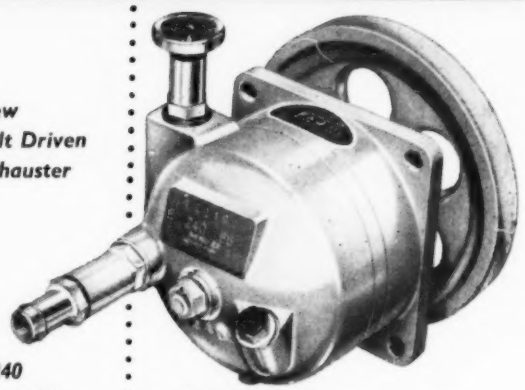

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★ Very High Efficiency
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# would you mix *this* with **your** engine oil?

No! But all this horrible stuff would have been in the engine oil if it had not been taken out as fast as it accumulated by the Glacier centrifugal extractor fitted in the lubricating oil system. The pile of contaminant shown is one "filter full", removed from a Glacier GF2 in one cleaning, after a run of 600 hours. It weighs over two pounds — 1,060 grams.

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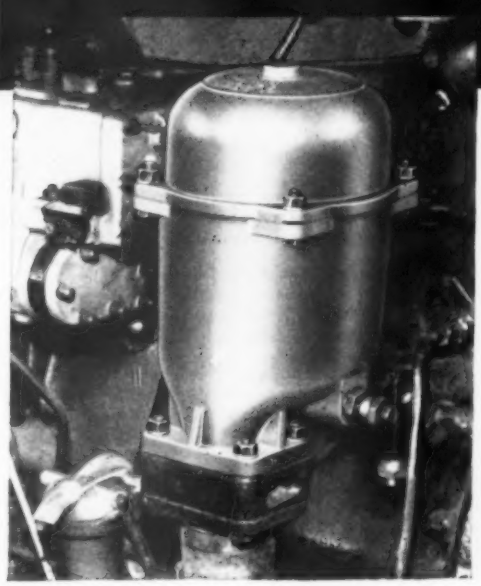

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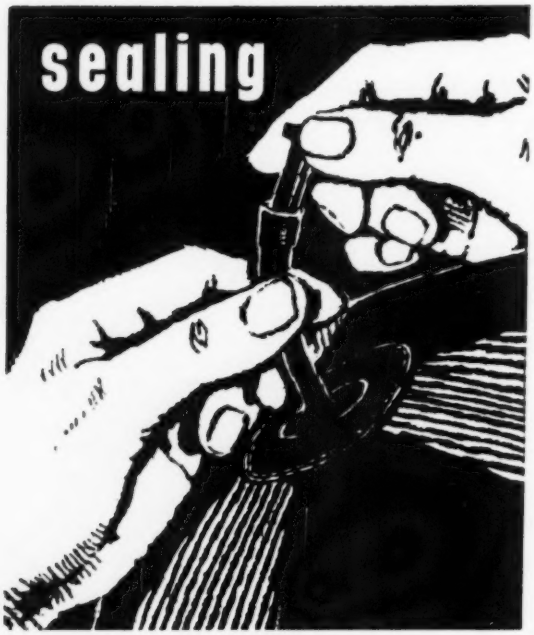
***All correspondence on Filters to be addressed to:- The Glacier Metal Co. Ltd., Kilmarnock, Ayrshire, Scotland***

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**Vibration and shock reduction.** Tesamoll is ideal for mounting delicate instruments to eliminate the effect of shock, chatter and vibration, or to compensate for uneven surfaces.

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**Made for the job.** Tesamoll is specially manufactured for industrial use. The urethane foam is permanently and chemically bonded to the tough P.V.C. support which carries the pressure-sensitive adhesive, which is protected by an easily removable corrugated P.V.C. covering.

**Send for free booklet and samples.** Tell us about your problems and we will send you samples of Tesamoll to test, together with a technical booklet giving physical, electrical and chemical characteristics as well as the range of thicknesses, widths and prices. Write today for your copy.

Tesamoll

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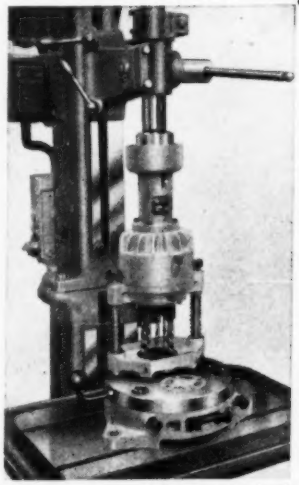

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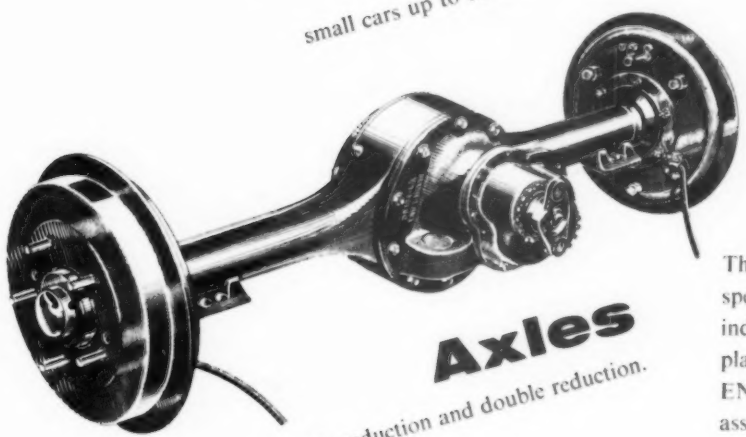

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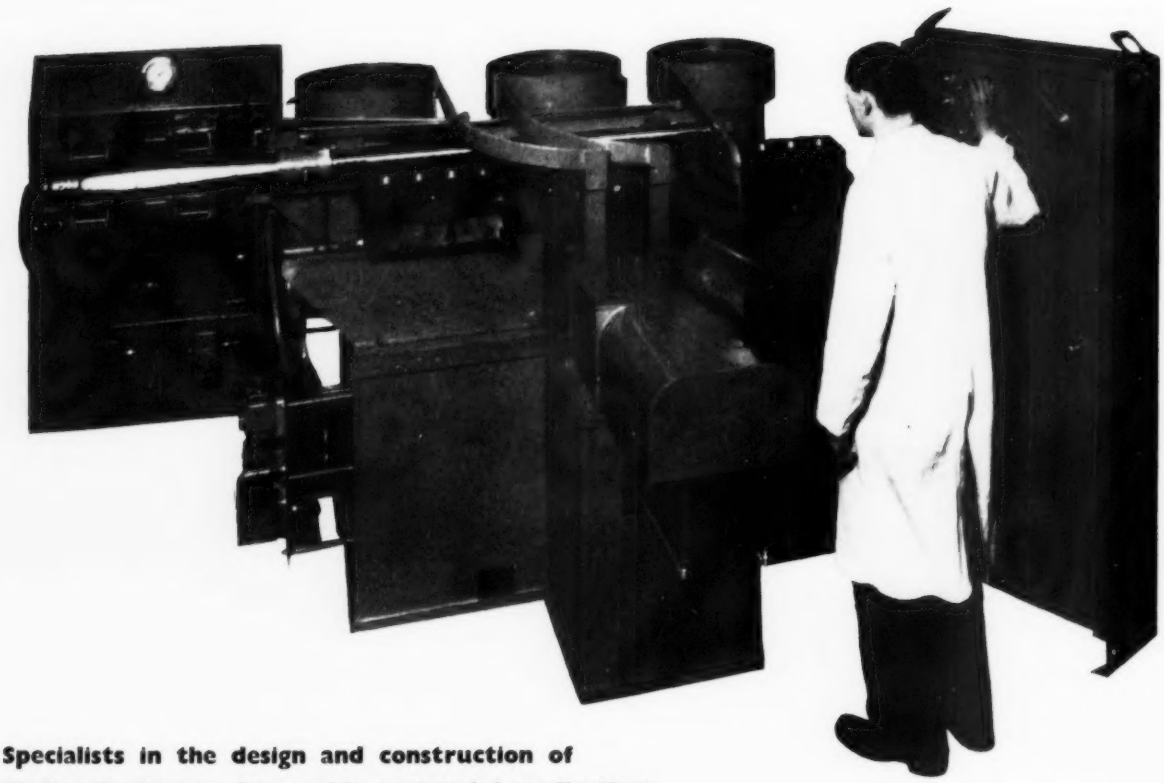
AP107

HI-TON

# Special Presses for high-output Production



**Specialists in the design and construction of Hydraulic Presses for a wide variety of applications**

Hi-Ton specialise in the design and manufacture of individual hydraulic presses for operation in mass production lines. The example illustrated has recently been supplied to an automobile manufacturing company and inserts three core plugs into the cylinder block, the plugs being fed to the rams by independent hoppers. The cylinder blocks are transferred automatically in and out of their operating position. The time cycle of this machine is 45 seconds.

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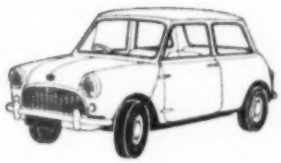
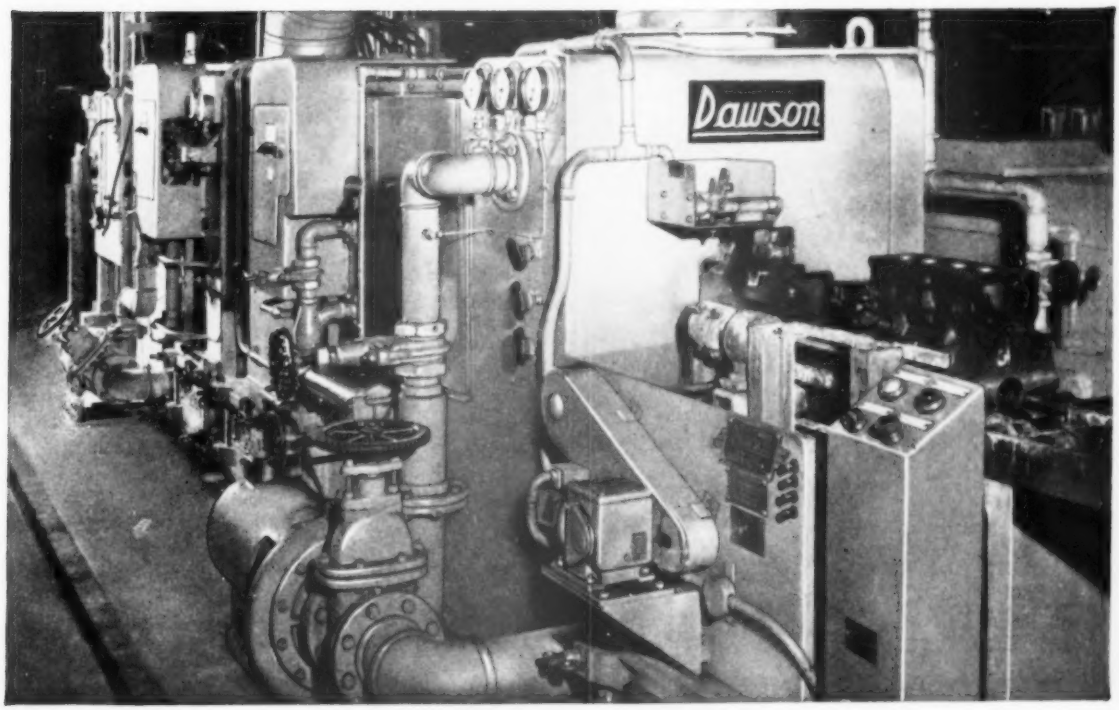
MF360

# Dawson Automatic cylinder block Washer for the new AUSTIN se7en






The fully automatic Dawson machine illustrated is used to remove all cast iron swarf and cutting oils from the Austin Seven cylinder blocks before engine assembly. It is continuous in operation and handles up to 80 blocks per hour. The blocks are carried through the machine intermittently, pausing at each cleaning station in accordance with a controlled time cycle. An important feature of the machine are the swing type hydraulically operated jetting boxes (patent applied for) incorporated in the washing sections. Each of these has a main nozzle which is spring pressed on the main oil bore gallery at each end of the cylinder block, making a liquid tight connection. Thus the gallery is positively flushed from both ends, the liquid passing through all subsidiary ducts before escaping from the block. In addition, these jet boxes have secondary nozzles accurately registered with all the bores and recesses at the ends of the cylinder blocks.

This high precision cleaning plant is only one of the many Dawson machines installed in the Austin Seven production line.

**Dawson** **DEGREASING AND CLEANING PLANT**

*Sole Distributors*
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***Manufacturers:*** **DAWSON BROS. LTD., GOMERSAL, Near LEEDS. Tel. Cleckheaton 3422 (5 lines)**
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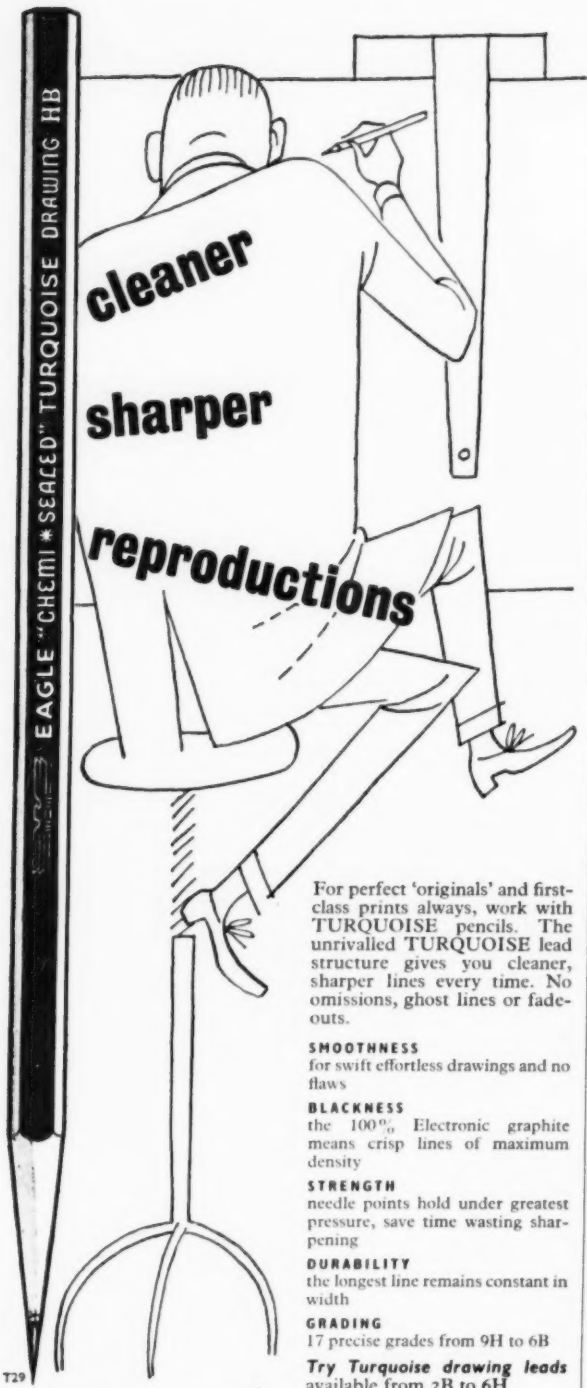


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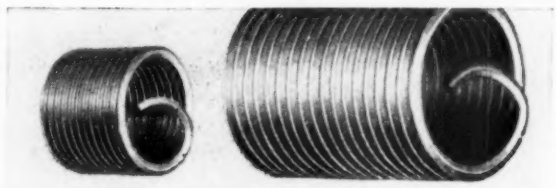

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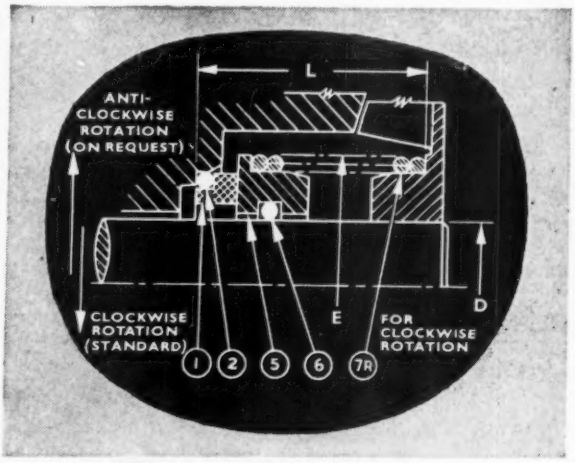


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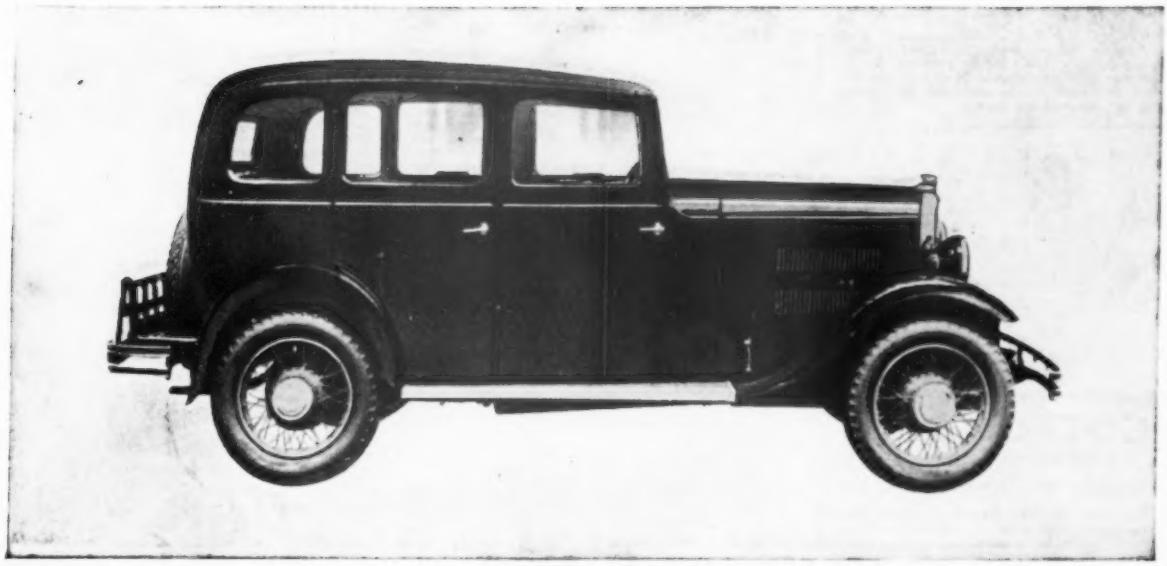

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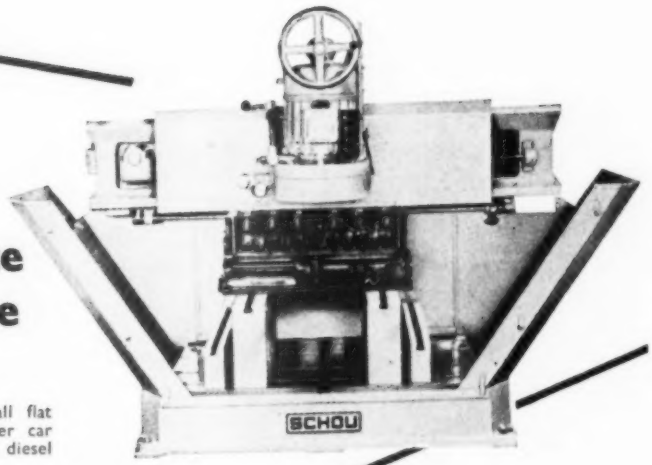


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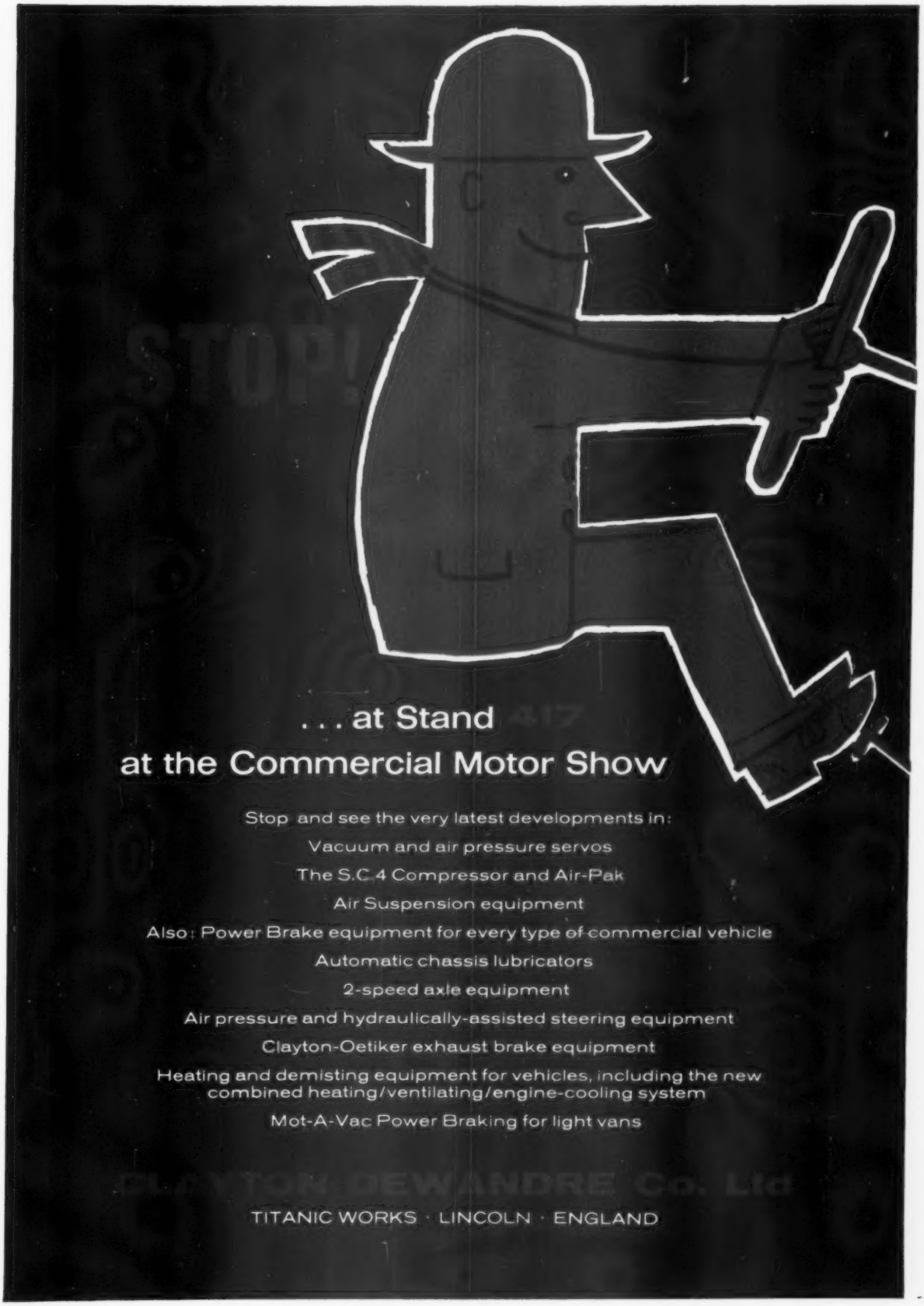
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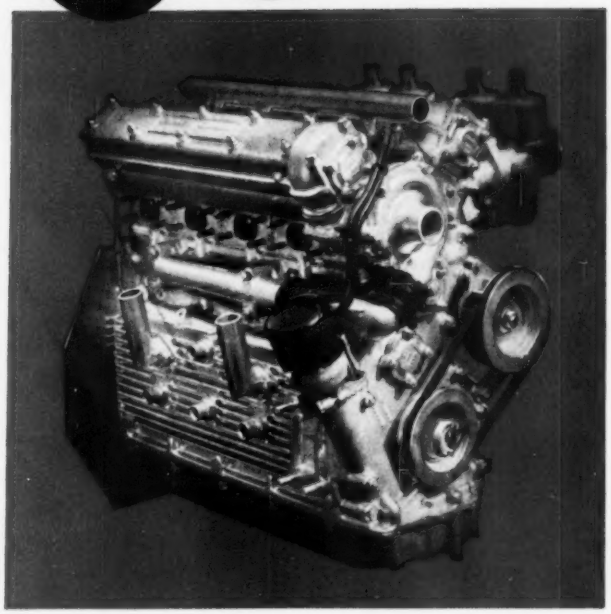

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